Submission to the

Climate Change Commission

on the **Review of the 2050 Target**

September 2023

On behalf of

Beef+Lamb NZ, DairyNZ and Federated Farmers

Contents

The primary piece of scientific evidence we submit is a report commissioned by Beef+Lamb NZ, DairyNZ and Federated Farmers from climate change experts at Oxford University and Cranfield University, entitled *Agriculture emissions and warming in Aotearoa New Zealand to 2050: Insights from the science*. This report is attached in Appendix 1. The report assesses New Zealand's current legislated targets to 2050 and analyses these through the lens of relative contributions of different gases to warming.

We believe this report provides additional context that is relevant to New Zealand. It demonstrates a significant development in the scientific understanding of what is required for New Zealand to achieve no further warming from biogenic methane since the commencement of Section 5T of the Climate Change Response Act in 2019.

These advancements have a direct relationship to setting appropriate emissions reduction targets for biogenic methane and should be considered by the Climate Change Commission to inform a review of the2050 target.

We request not only that the Climate Change Commission undertake a review of the current targets set for biogenic methane but also to do so on a warming approach. A warming approach would require that the temperature outcomes of targets be transparently outlined and adequately considered. Adopting a 'warming approach' for reviewing and setting targets aligns with the sound science that informed Parliament's decision to set split gas emission reduction targets in the 2019 Climate Change Response (Zero Carbon) Amendment Act.

Executive summary

1. Safeguarding the environment while maintaining a sustainable and internationally competitive agricultural sector is very important to our farmers, customers, consumers, and nation. We recognise the agricultural sector's responsibility to play its part in contributing to New Zealand's greenhouse gas reduction efforts. New Zealand farmers are already taking action.

2. Beef+Lamb NZ, DairyNZ and Federated Farmers welcome the opportunity to provide input to the first review of New Zealand's emissions reduction targets. The review is an opportunity to ensure our policy settings are equitable and reflect the latest developments in scientific knowledge, international action, and the socio-economic context in New Zealand.

3. This submission and accompanying evidence provide a justification for a review of the 2050 Target[1] under the Climate Change Response Act on the basis of significant change to the scientific understanding of climate change (Section 5T(2)(ii) of the Act).

[1] The 2050 Target is defined by the Climate Change Commission's consultation document as the biogenic methane targets for 2030 and 2050, as well as the net zero 2050 target.

4. The current methane targets in the Act were derived from an IPCC report that were incorrectly applied domestically. New research explains that short- and long-lived gases have a different effect on temperature and should be measured accordingly.

5. This new research also demonstrates that the current methane targets are too high and need to be amended.

6. Key findings of the evidence we submit are:

    - The current 47% reduction in methane target would see methane offset all of the expected additional warming created by carbon dioxide and nitrous oxide between 2022 and 2050, bringing New Zealand's economy wide cumulative warming back to 2022 levels by 2050.
    - A 24% reduction in methane by 2050 would see methane offset all additional warming from carbon dioxide and nitrous oxide between 2027 and 2050, bringing New Zealand's economy wide cumulative warming back to 2027 levels by 2050.
    - In both cases, New Zealand's total contribution to global warming would peak in the mid- to late-2030s thanks to the combination of CO_2, N_2O and methane reductions.
    - Many developed countries have pledged to achieve net zero by 2050 at the latest. In countries where CO_2 is the dominant contributor to warming, which is the majority, this implies their total contribution to global warming peaks around 2050.

    The following table summarises four warming scenarios from the new research for methane and its impacts in target setting:

Scenario	Achieve the same contribution to warming as the 2050 net zero target set for long lived GHG	Achieve net zero additional warming from methane from 2020 levels (assuming current global commitments are achieved)	Achieve net zero additional warming from 2020 levels (assuming global emissions mitigation significantly accelerates)	Reductions in methane offset the additional warming from all future long-lived emissions from today's levels
2050 methane reduction required	+35%	-15%	-27%	-47%

7. The methane reduction scenarios presented in this report (and in column 2 & 3 in the table above) are still a very ambitious contribution from the agriculture sector because they would see methane contribute net zero additional warming **from 2020** levels as opposed to **2050** for long-lived gases.
8. On the basis of this new research, Beef + Lamb NZ, DairyNZ and Federated Farmers request that the Climate Change Commission recommend a review to the current methane targets based on a 'warming approach'.
9. A warming approach estimates the impact on global temperatures resulting from reductions in each greenhouse gas. A warming approach would be a more accurate measure for methane target setting relative to simply using emissions as a proxy. This is because changes in biogenic methane emissions rarely accurately correlate with temperature impacts when the GWP100 metric is used.
10. The Paris Agreement's goal is to limit the global average temperature increase to well below 2 degrees above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels. It therefore makes sense that a country's climate change objectives consider how much they are contributing to warming, what is being demanded by each GHG on a warming basis and what other countries are doing from a warming perspective.
11. Transparency is needed on the methods used to determine long-term targets so that equity can be achieved between sectors.
12. At present, the principles used to define the 2050 Target is not clear. We would recommend the Commission run a number of scenarios to look at the relative warming contribution of different GHGs between now and 2050 based on emissions reductions assumed, including no additional warming by methane from 2050.
13. Other factors that should also be taken into account include available technology, impact on global food security, emissions leakage, impact on regional economies, and impact on the national economy.
14. Adopting a 'warming approach' to target setting would correct the current disconnect between how emissions are measured and the warming they cause. This approach would also mean New Zealand's emissions inventory, emissions budgets, emissions targets, the NZ ETS and New Zealand's NDC would accurately reflect warming.
15. The current targets are not just inequitable, but will also be costly and undermine farmer viability. The impacts of using the wrong basis for methane targets are significant for the country.
16. While important investment is underway to address gaps in mitigation technologies available to lower emissions from the agricultural sector,

commercially viable options available to farmers remain very limited and do not match the assumptions made at the time the 2050 targets were set.

Background

The New Zealand agricultural sector is committed to playing its part in the global response to the threat of climate change. We have active programmes to support farmers as they manage their emissions and build their resilience to a changing climate.

Section 5T of the Climate Change Response Act (the Act) sets out the criteria the Commission is to use to determine whether a review of the 2050 target is justified. We submit that, in the event a decision is made to review the target, the Commission should be guided by the Purpose of the Act in determining what a new target should be.

In particular, the Act's purpose is to provide a framework by which New Zealand can develop and implement clear and stable climate change policies that:

a) contribute to the global effort under the Paris Agreement to limit the global average temperature increase to 1.5° Celsius above pre-industrial levels; and

b) enable New Zealand to meet its international obligations under the UNFCCC and Paris Agreement.

In determining what a new target for methane might be for New Zealand, we submit that the Commission look to Article 4.1 of the Paris Agreement. This Article sets out what Parties aim to do to achieve the long-term temperature goal set out in Article 2 (well below 2°C, and pursuing efforts to limit to 1.5°C).

Article 4.1 states that Parties aim to peak and rapidly reduce greenhouse gas emissions "**in accordance with best available science**, so as to achieve **a balance between anthropogenic emissions by sources and removals** by sinks of greenhouse gases in the second half of this century, on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."

This submission notes that the "best available science" has evolved since the Act was passed. The IPCC has released its sixth assessment report (AR6) that states:

> *"For a stable global warming from non-CO2 climate agents (gas or aerosol) their effective radiative forcing needs to gradually decrease. Cain et al. (2019) find this decrease to be around 0.3% yr –1 for the climate response function in AR5 (Myhre et al., 2013b)."*

This 0.3% per year figure referenced in the IPCC's AR6 report is substantially different from that adopted in New Zealand legislation for biogenic methane. The current methane targets in the Act are closer to a rate of 1% reduction per year. These methane targets are made more challenging by being absolute (not intensity-based) and gross (not allowing the use of any offsets). The research we submit shows the significant temperature impact of a faster rate of reduction of methane emissions in New Zealand.

The second element of Article 4.1 is the aim of "to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century on the basis of equity, and in the context of sustainable development and efforts to eradicate poverty."

Here, we submit that anthropogenic methane emissions are balanced by removals naturally when methane emissions peak and reduce. Our evidence shows that, when taking a warming approach, this reduction is less than that which is currently legislated.

We note that the research presented asks the question of what methane reduction is required to achieve no further warming immediately. This would go beyond the Paris Agreement goal of achieving a balance of emissions and removals in the second half of the century.

The other concepts mentioned in Article 4.1 are equity and sustainable development. We offer three observations:

1. New Zealand has adopted a target of net-zero long lived gases by 2050. This represents an approach of no further warming from 2050. Equity between sectors would demand that a similar approach is used for biogenic methane. At the very least, clear principles should be set for how targets are determined and applied equally to biogenic methane and long-lived gases. If a more ambitious warming approach is to be taken for methane relative to other emissions, this should be transparently acknowledged and justified.

2. New Zealand is currently achieving a large portion of our emissions reductions via forestry offsets. These offsets are driving sustainability concerns from a social, cultural, environmental and economic perspective.

3. New Zealand is a developed net food exporting nation that is a signatory to the 2030 Agenda for Sustainable Development. New Zealand's domestic policy should, therefore, acknowledge the country's role in the global economy and food system. Policy settings should enable New Zealand to make a positive contribution towards overcoming global issues, such as ending global poverty and ending hunger, while also meeting climate targets.

Scientific understanding of climate change

The Act obtained Royal Assent in November 2019. The most recent IPCC reports at that time were the Special Reports on 'Global Warming of 1.5C', 'Ocean & Cryosphere' and 'Land' (see Figure 1).

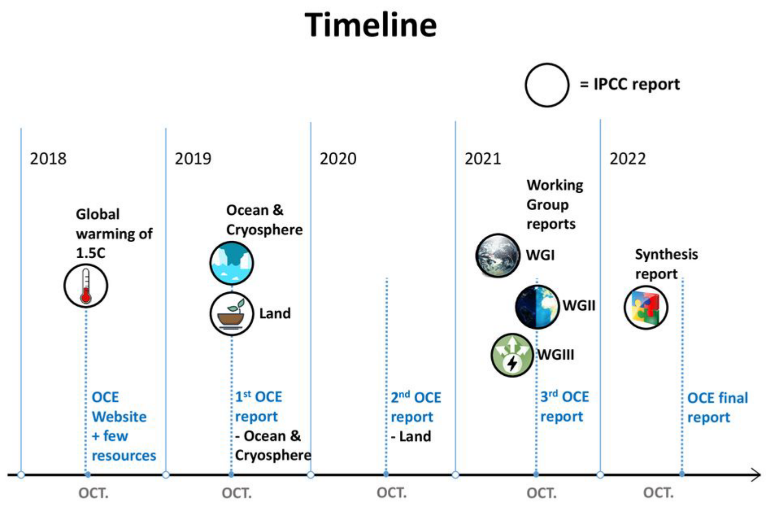

Figure 1: Timeline of IPCC reports since Act passed (Source: IPCC Working Group 1 Technical Support Unit)

Since the Act gained Royal Assent, the IPCC has released its full Sixth Assessment Report. This includes all three working group reports, the Summary for Policy Makers and the Synthesis Report.

Substantial new evidence emerged in the AR6 First Assessment Report in regards to reduction of short lived forcers. In particular, IPCC AR6 WG1 states:

> *"Following AR5, this Report does not recommend an emissions metric because the appropriateness of the choice depends on the purposes for which gases or forcing agents are being compared. Emissions metrics can facilitate the comparison of effects of emissions in support of policy goals. They do not define policy goals or targets but can support the evaluation and implementation of choices within multi-component policies (e.g., they can help prioritize which emissions to abate). The choice of metric will depend on which aspects of climate change are most important to a particular application or stakeholder and over which time horizons. Different international and national climate policy goals may lead to different conclusions about what is the most suitable emissions metric (Myhre et al., 2013b).*
>
> *Global warming potentials (GWP) and global temperature-change potentials (GTP) give the relative effect of pulse emissions, that is, how much more energy is trapped (GWP) or how much warmer (GTP) the climate would be when unit emissions of different compounds are compared (Section 7.6.1.2). Consequently, these metrics provide information on how much energy accumulation (GWP) or how much global warming (GTP) could be avoided (over a given time period, or at a given future point in time) by avoiding the emission of a unit of a short-lived greenhouse gas compared to avoiding a unit of CO2. By contrast, the new metric approaches of combined GTP (CGTP) and GWP* closely approximate the additional effect on climate from a time series of short-lived*

> *GHG emissions, and can be used to compare this to the effect on temperature from the emission or removal of a unit of CO2 (Section 7.6.1.4; Allen et al., 2018b; Collins et al., 2020)."*[2]
>
> *"For a stable global warming from non-CO2 climate agents (gas or aerosol) their effective radiative forcing needs to gradually decrease (Tanaka and O'Neill, 2018). Cain et al. (2019) find this decrease to be around 0.3% yr –1 for the climate response function in AR5 (Myhre et al., 2013b)."*[3]
>
> *"Note that GWP and GTP metrics were not designed for use under a cumulative carbon dioxide equivalent emissions framework (Shine et al., 1990, 2005), even if they sometimes are (e.g., Cui et al., 2017; Howard et al., 2018) and analysing them in this way can give useful insights into their physical properties. Using these standard metrics under such frameworks, the cumulative CO2 equivalent emissions associated with methane emissions would continue to rise if methane emissions were substantially reduced but remained above zero. In reality, a decline in methane emissions to a smaller but still positive value could cause a declining warming. GSAT changes estimated with cumulative CO2 equivalent emissions computed with GWP-20 matches the warming trend for a few decades but quickly overestimates the response. Cumulative emissions using GWP-100 perform well when emissions are increasing but not when they are stable or decreasing. Cumulative emissions using GTP-100 consistently underestimate the warming. Cumulative emissions using either CGTP or GWP* approaches can more closely match the GSAT evolution (Allen et al., 2018b; Cain et al., 2019; Collins et al., 2020; Lynch et al., 2020)."*[4]

While the 0.3% reduction in non-CO2 climate agents is referenced in the IPCC's sixth assessment report, this figure is for all non-CO2 agents, and for the globe generally. Our research sought to understand what this figure was for New Zealand methane.

Short and long-lived greenhouse gases have a different effect on temperature

Methane, as a short-lived, flow gas, does not accumulate in the atmosphere in the same way as long-lived gases. Although much more effective at trapping heat than long-lived gasses, methane emitted today will have largely disappeared after 12 years. Short-lived gases maintain warming if they are sustained, increase warming if they are increased, and reverse warming if they decrease.

Carbon dioxide and nitrous oxide are long-lived, stock gases. Nitrous oxide stays in the atmosphere for centuries, and carbon dioxide for millennia. Therefore, every unit emitted today increases its concentration in the atmosphere and adds to the warming caused by past emissions. Long-lived gases add to warming if they are increasing,

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[2] Forster, P., T. Storelvmo, K. Armour, W. Collins, J. L. Dufresne, D. Frame, D. J. Lunt, T. Mauritsen, M. D. Palmer, M. Watanabe, M. Wild, H. Zhang, 2021, The Earth's Energy Budget, Climate Feedbacks, and Climate Sensitivity. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press, pp. 1017

[3] Ibid, pp. 1015

[4] Ibid, pp. 1016

decreasing or sustained. Only when long-lived gases reduce to zero do they no longer contribute to further warming.

New Zealand adopted a split gas approach to targets, recognising that biogenic methane needs to reduce, but not reach net zero in the same way long-lived gases do to limit global warming to 1.5 degrees. The soundness of this approach has been affirmed by the IPCC in its sixth assessment report.

> *"In summary, new emission metric approaches such as GWP* and CGTP are designed to relate emission changes in short-lived greenhouse gases to emissions of CO_2 as they better account for the different physical behaviours of short and long-lived gases. Through scaling the corresponding cumulative CO_2 equivalent emissions by the TCRE, the GSAT response from emissions over time of an aggregated set of gases can be estimated. Using either these new approaches, or treating short and long-lived GHG emission pathways separately, can improve the quantification of the contribution of emissions to global warming within accumulative emission framework, compared to approaches that aggregate emissions of GHGs using standard CO_2 equivalent emission metrics."*[5]

Split gas targets are a necessary, but not sufficient step, to accurately assess how New Zealand is tracking towards its contribution to global warming. Currently there is a disconnect between how emissions are measured and the warming impact they cause, resulting in a misalignment of policy with the temperature goal of the Paris Agreement.

This misalignment is because New Zealand monitors progress by aggregating emissions to carbon dioxide equivalent, despite the science being clear that this is a poor policy choice. This approach fails to accurately consider the respective warming impacts of different gases and puts New Zealand at risk of overestimating the methane reduction targets we need to achieve as a country. This creates unnecessary and inequitable social and economic impacts for the agricultural sector, and therefore New Zealand, as a result.

Instead, New Zealand policymakers can update policy settings to both more accurately inform burden-sharing decisions and better align New Zealand climate policy with the core Paris Agreement's temperature goal by:

- Aligning the 2050 target with a warming approach.
- Consistently taking a science based split gas approach in other critical climate policy, such as in emissions budgets and our NDC.

If you want to limit temperature change, then you need to measure temperature change

The Global Warming Potential (GWP), despite its name, does not measure warming. The GWP of a greenhouse gas represents its ability to trap extra heat in the atmosphere over

[5] Ibid, pp. 928

time relative to carbon dioxide. This is commonly calculated over 100 years and is known as GWP100. While GWP100 can work well for measuring gases with a long lifetime in the atmosphere, it is inaccurate for short-lived gases such as methane – over-stating the warming impact of methane emissions by three to four times when emissions are stable.

This is reflected in the IPCC's First Assessment Report, which was the report to first propose the GWP. The First Assessment Report states, in relation to the GWP metric included in their report,

> *"It must be stressed that there is no universally accepted methodology for combining all the relevant factors into a single global warming potential for greenhouse gas emissions. In fact there may be no single approach which will represent all the needs of policy makers. A simple approach has been adopted here to illustrate the difficulties inherent in the concept, to illustrate the importance of some of the current gaps in understanding and to demonstrate the current range of uncertainties. However, because of the importance of greenhouse warming potentials, a preliminary evaluation is made."*

Despite this warning, policy makers have adopted the GWP metric, often without questioning it's validity, appropriateness or applicability.

Modelling radiative forcing or using a metric such as GWP*,is a far more accurate method for accounting for methane emissions and the impact on temperature. This time-based metric still uses GWP_{100} values but adapts them to take account of methane's short lifetime and other behaviour.

To demonstrate the difference, using GWP100 agriculture contributed 51% of the total emissions in New Zealand in 2020, most of which was from methane. However, in the new research, modelling radiative forcing the proportion of the agricultural sector's contribution to additional warming between 1990 and 2020 is 37%, and of that methane is 16%.

All metrics and modelling are a tool not a solution. Using appropriate metrics and modelling that account for different warming potential of short-lived gasses allow policy decisions around burden sharing to take place transparently, and on a level playing field. Relying on a metric that overstates the impact of agricultural emissions (if emissions are stable or declining) when setting targets will unfairly punish farmers.

The attached report's findings on metrics are aligned with the findings of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report[6]. The IPCC report highlighted the need to split out short-lived gases and long-lived gases to have certainty in meeting temperature targets:

> *"The choice of emission metric affects the quantification of net zero GHG emissions and therefore the resulting temperature outcome after net zero emissions are achieved. In*

[6] In particular, chapter 7 of AR 6 Climate Change 2021: The Physical Science Basis from the IPCC's Working Group I and chapter 2 of AR6 Climate Change 2022: Mitigation of Climate Change from the IPCC's Working Group III, plus supplementary material associated with the latter.

> *general, achieving net zero CO2 emissions and declining non-CO2 radiative forcing would be sufficient to prevent additional human-caused warming. Reaching net zero GHG emissions as quantified by GWP-100 typically results in global temperatures that peak and then decline after net zero GHGs emissions are achieved, though this outcome depends on the relative sequencing of mitigation of short-lived and long-lived species."*
>
> *"In contrast, reaching net zero GHG emissions when quantified using new emission metrics such as CGTP or GWP* would lead to approximate temperature stabilization (high confidence) {7.6.2}." "By comparison expressing methane emissions as CO2 equivalent emissions using GWP-100 overstates the effect of constant methane emissions on global surface temperature by a factor of 3-4 over a 20-year time horizon (Lynch et al., 2020, their Figure 5), while understating the effect of any new methane emission source by a factor of 4-5 over the 20 years following the introduction of the new source (Lynch et al., 2020, their Figure 4)."*

The current methane targets in the Climate Change Response Act were derived from an IPCC report that were incorrectly applied domestically

New Zealand's methane targets were derived in part from the IPCC special report on pathways towards 1.5 degrees. That report acknowledged that methane does not need to go to zero and that separate targets for methane were appropriate.

However, the authors of this report specifically said that the pathways set out in that report should not be used directly by countries for their targets, saying that the strategies "*illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements*." In other words, they are just example strategies, chosen by the authors of the report, and do not represent a central forecast.

The current methane targets are too high

The research finds that a 47% reduction in methane emissions by 2050, following a 10% reduction in methane emissions between 2020 and 2030, and linear reductions to net zero from 2020 to 2050 in CO_2 and N_2O emissions would see methane reductions essentially offsetting all of New Zealand's additional warming from CO_2 and N_2O emissions. This would bring New Zealand's economy-wide cumulative warming back to 2022 levels, meaning New Zealand would cause net zero additional warming from 2022 by 2050.

The report finds that a 24% reduction in methane emissions by 2050 combined with linear reductions to net zero in CO_2 and N_2O to net zero by 2050 from 2020 would see New Zealand achieve net zero additional warming as an economy from 2027.[7]

In both cases, New Zealand's total contribution to global warming would peak in the mid- to late-2030s thanks to the combination of CO_2, N_2O and methane reductions.

[7] Note the 24-47% reduction range assumes the rest of the world pursues current emissions reduction goals up to this time.

A net-zero 2050 target for long-lived gases represents a target of no further warming from 2050, but those gases will be adding new warming between now and 2050.

The report quantified the expected amount of additional warming from carbon dioxide and nitrous oxide in New Zealand between now and 2050. It found that as the long-lived emissions lead to additional warming over this period, methane emissions would have to rise by 35% over this period to match the same level of additional warming.

The report found that reducing biogenic methane emissions by 15% by 2050 would represent net zero additional warming by methane in New Zealand from 2020 levels, assuming global mitigation remains on current trajectories.

Reducing biogenic methane emissions by 27% by 2050 would represent net zero additional warming from methane from 2020 levels, if global emissions are reduced on a trajectory that would limit global warming to 1.5C.

The following table summarises four warming scenarios from the new research for methane and its impacts in target setting:

Scenario	Achieve the same contribution to warming from methane as the 2050 net zero target set for long lived GHG	Achieve net zero additional warming from methane from 2020 levels (assuming current global commitments are achieved)	Achieve net zero additional warming from methane from 2020 levels (assuming emissions mitigation efforts significantly accelerate)	Reductions in methane offset the additional warming from all future long-lived emissions from today's levels
2050 methane reduction required	+35%	-15%	-27%	-47%

This demonstrates that the current legislated range for biogenic methane reductions of 24-47% by 2050 is asking the agriculture sector to go above and beyond other sectors of the economy, whose emissions will make an ongoing contribution to global warming, even after they reach net zero in 2050 as per the current target.

If a warming approach is not adopted, we request the Commission make clear on what basis they justify a target that asks the sector to do more than add no additional warming, and to do this faster than other sectors.

Global action

The level of warming from New Zealand's methane emissions relies and depends upon the global level of methane in the atmosphere.

This plays out at the margin when we consider what reductions New Zealand needs to make. The lower the expected global concentration of methane, the bigger the impact of our emissions, and the greater the reductions we need to make to be warming neutral.

What does international action tell us about what New Zealand's methane targets could be?

Our research considers two potential pathways for future warming using Shared Socioeconomic Pathways (SSPs). SSPs can be used to demonstrate a range of climate change scenarios, accounting for lower to higher levels of global action.

The two pathways that were modelled in the report were SSP-119 and SSP-245. Using these pathways, both scenarios would add no additional warming from 2020 depending on how quickly other countries reduce their emissions.

SSP-119 Scenario:

- SSP-119 is the pathway where countries have significantly increased their current levels of ambition to reduce emissions in such a way that the global increase in temperature is held to 1.5 degrees above pre-industrial levels. The world to date has already warmed by 1.2 degrees above pre-industrial levels. The AR6 synthesis report said that GHG emissions would need to reduce 43% by 2030 on 2019 levels to be consistent with achieving 1.5 degrees. The World Meterological Organisation has reported that there is a 66% likelihood of exceeding the 1.5C threshold in at least one year between 2023 and 2027.
- If countries were to significantly increase their current levels of ambition, and we are able to keep temperature increases below 1.5 degrees, then a 27% reduction in methane would see New Zealand methane not contributing any additional warming from 2020 levels.

SSP-245 Scenario:

- SSP-245 is a moderate ambition scenario and is accepted as a reasonable proxy for current global policies to mitigate climate change: i.e. if countries reduce their emissions by the amount that they have currently committed then SSP-245 is a likely temperature increase outcome.
- If countries globally meet their existing commitments, then a 15% reduction in methane would see New Zealand methane not contributing any additional warming from 2020 levels.

This phenomenon means we must consider the scientific implications of global action in our domestic target setting. Ignoring this dynamic risks unfairly asking more of our farmers and growers.

It is important to note that either pathway is ambitious. Methane from New Zealand agricultural production would be adding no additional warming **from** 2020 levels, while carbon dioxide and nitrous oxide would continue to add warming until 2050.

A methane reduction target of no additional warming from 2020 would be world leading:

- New Zealand's emissions profile is unique, for most developed countries, CO2 is the dominant gas (70-90% of their emissions). Most developed countries have a target of net zero by 2050, which is generally considered to be ambitious. This means the rest of the world is effectively aiming to peak global warming around 2050. By this time, New Zealand would already have peaked (around 2035-2040) and started reducing its contribution to global warming, returning back to 2022 or 2027 levels of warming.
- New Zealand demonstrated leadership when taking a science-based approach and setting split gas domestic targets in 2019. Improving these split gas targets by developing a methane reduction target of no additional warming from 2020 levels would demonstrate that New Zealand is tackling the issues that arise in standard carbon accounting as short-lived emissions (such as methane) increase proportionally. The unusual nature of New Zealand's economy and emissions inventory has presented New Zealand with this challenge earlier than most countries.

It is also worth noting that currently 48 nations have no net zero target, 60 nations have a proposed target, 8 have a pledged net zero target, 49 nations have a policy document for a net zero target, 27 nations have a net zero target in law and 6 nations have (self-declared) achieved the target.[8]

New Zealand is an efficient agricultural producer

The need for international action on methane reductions has grown in awareness as evidenced by the establishment of the Global Methane Pledge at COP26. Participants, including New Zealand, have agreed to voluntary actions to limit methane emissions. The Pledge focuses on achieving "*all feasible reductions from the energy and waste sectors*", acknowledging that the fossil fuel sector has the greatest potential internationally for targeted mitigation by 2030, and seeks "*abatement of agricultural emissions through technology innovation as well as incentives and partnerships with farmers*."[9]

New Zealand is alone globally in legislating to price biogenic methane emissions. We are distinct in the way we have set a dedicated biogenic methane reduction target in

[8] https://zerotracker.net/
[9] Homepage | Global Methane Pledge

national legislation. New Zealand farmers also cannot rely on production subsidies like many of their offshore counterparts.[10]

New Zealand meeting emissions reduction targets by simply reducing food production is a poor outcome not only for rural communities, regional economics and the overall New Zealand economy, but also a poor outcome for global food security and the atmosphere. New Zealand farmers should be empowered to farm better, not simply forced to farm less.

New Zealand produces beef, lamb and dairy products in efficient, unsubsidised and pasture-based systems where livestock are free to graze and move around outside. As a result, beef, lamb and dairy is produced with levels of greenhouse gas emissions far below those seen in other countries. New Zealand farm systems are often the envy of the world and New Zealand should not reduce food production to meet domestic targets while decreasing global food security and increasing global emissions (as emissions are leaked overseas).

Regarding the likelihood of emissions leakage, a report commissioned by He Waka Eke Noa and carried out by Resource Economics states:

> *"Using the 50% scenario from Table 10 suggests that, for every tonne of emissions reduced in New Zealand from the beef sector from reductions in output, emissions would be expected to rise elsewhere by 1.15 tonnes, an overall increase in global emissions of 15%. The equivalent estimates for sheep and dairy production are emissions increases of 7% and 30% respectively. The 50% assumption is obviously arbitrary and actual leakage rates if pricing was introduced to New Zealand are highly uncertain…*
>
> *We have deliberately not defined "small marginal changes" as this too is imprecise. But we suggest it is reasonable to assume lost agricultural production from New Zealand will lead to emissions leakage and increases in global emissions."*[11]

New Zealand farmers are committed to building on this leadership position and working towards a warming-neutral New Zealand agricultural sector by 2050. Transitioning to a low-emissions economy will require significant changes from all sectors of the economy and farmers want to both play their part and be a part of the solution to climate change.

Dairy Sector efficiency

In New Zealand, the dairy sector's emissions profile has stabilised and is tracking downwards. The latest national greenhouse gas inventory (using a GWP100 metric) shows that agriculture makes up 49% of New Zealand's emissions (down from 50% in 2020). Dairy makes up 22.7% of emissions (down from 23% in 2020). The proportion of

[10] Climate Change Commission literature review international comparison: International policy comparison
[11] https://hewakaekenoa.nz/wp-content/uploads/2022/06/FINAL-Pricing-agricultural-GHG-emissions-impacts-on-emissions-leakage.pdf

dairy emissions to total sector-wide emissions has decreased 0.8% in the past year due to a decrease in cow numbers and lower synthetic fertilizer use.[12]

As a sector New Zealand dairy is amongst the world's most efficient. A 2021 AgResearch report on carbon footprint for milk from dairy cows showed that New Zealand is the most carbon efficient producer of dairy milk out of the 19 countries included in the study (with a footprint of 0.74 kg CO2e/kg FPCM - 70% lower than the FAO global average).[13]

Due to the world-leading emissions efficiency of New Zealand farmers and the close correlation between emissions and economic efficiency, it will be very difficult to continue this trend without breakthrough technology that decouples the relationship between methane and dry matter intake.

Red meat sector efficiency

The latest Lifecycle Assessment (LCA) showed that New Zealand sheepmeat and beef is amongst the lowest in the world and when a warming approach is taken to measurements and combined with on farm vegetation, sheepmeat has a negative footprint (no additional warming has been added in the last 20 years).

The impact of New Zealand's methane reductions on global temperatures depends significantly on indirect impacts like whether the rest of the world steps up livestock production to compensate for any reduced production in New Zealand. Reducing efficient food production in New Zealand to meet domestic climate targets would lead to offshoring these emissions to less greenhouse gas efficient producers elsewhere, ultimately producing worse climate outcomes.

Continued global inaction will result in increased adverse events in New Zealand. How we upscale adaptation and build greater resilience to climate change impacts alongside our mitigation efforts will only become more urgent. We encourage the Commission to consider further work on scenario planning to investigate how New Zealand climate policy would shift under a range of scenarios where the rest of the world either acts or does not act on climate change.

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[12] Ministry for the Environment, New Zealand Greenhouse Gas Inventory 1990-2021: New Zealand's Greenhouse Gas Inventory 1990–2021 | Ministry for the Environment

[13] Mapping the carbon footprint of milk production from cattle: A systematic review

Distributional impacts

We encourage the Commission to take into account the distributional effect of emissions reductions asked of the agricultural sector when considering the warming impact of biogenic methane emissions.

The report demonstrates how the agriculture sector is being asked to do more than others in terms of reducing their impact on warming.

As noted above, the report finds that a 47% reduction in methane emissions by 2050 would see methane essentially offsetting all additional warming by $C02$ and N_20, bringing New Zealand's cumulative warming back to 2022 levels – essentially meaning New Zealand would cause net zero additional warming from 2022 by 2050 (and continue on that way as long as emissions reductions from methane were maintained). A 24% reduction in methane emissions by 2050 would see New Zealand achieve net zero additional warming as an economy from 2027.

This demonstrates that the current legislated range for biogenic methane reductions of 24-47% by 2050 is asking the agriculture sector to go above and beyond other sectors of the economy, whose emissions will make an ongoing contribution to global warming, even after they reach net zero emissions in 2050 as per the current target.

Equity implications

The required reduction in emissions should factor in what is technically, socially, and economically feasible for New Zealand. We believe that the targets must take the latest science into account, ensure they are rural-proofed and addresses the distributional impacts on rural communities.

The scientific evidence provided demonstrates how the agricultural sector is currently being asked to do more than others in terms of reducing its warming impact. The flow on implications of failing to consider the warming science have important flow on implications for sectoral equity and the economy.

We note the Government has delayed work on an Equitable Transitions Strategy to make sure that New Zealand's transition to a low emissions future is fair and inclusive. We are yet to see the details of this strategy. It will be essential to carefully consider the implications of transitional policies relating to the agricultural sector given its significance to rural communities and the wider New Zealand economy.

We believe that a target must be transparent and acknowledge the social and economic trade-offs made if it asks one sector to do more than others in terms of reducing their contribution to global warming. Any target that asks one sector for a greater contribution than others must be explicit of this choice.

New Zealand's economic or fiscal circumstances

Beef+Lamb NZ, DairyNZ and Federated Farmers request the Climate Change Commission consider evidence of the agricultural sector's significant contribution to the economy when reviewing the 2050 Target. The economic impacts of using the wrong basis for methane targets are significant for the country. The following evidence underscores the imperative of basing emissions reduction targets on the latest scientific information to avoid significant and unnecessary economic ramifications for New Zealand.

Agriculture's contribution to the economy

Our agricultural sectors are pillars of the national economy, and shock absorber for our regions. Significant changes and risks to New Zealand's economic and fiscal circumstances must be considered to ensure emissions reduction targets are not at the expense of the primary sector's economic contribution.

Dairy's contribution to the New Zealand economy

Sense Partners' commissioned data in the report entitled *"Solid Foundations: Dairy's economic contribution to New Zealand"* highlights the significant economic contribution of the dairy sector to New Zealand. This report is attached as evidence in Appendix 2A.

Some key takeaways from this report include:

- Dairy accounted for $11.3 billion (3.2%) of GDP in the year to March 2023.
- Of this, dairy farming contributes $8 billion (2.2% of GDP) and dairy processing contributes $3.4bn (0.9%).
- Māori businesses own around $4.9b billion in assets in the dairy sector.
- Dairy employs over 54,000 people directly.
- Dairy has a high employment share in South Taranaki (1 in 4 jobs), Westland (1 in 4.5 jobs), Southland (1 in 5 jobs).
- Dairy farming is a shock absorber for regional economies, maintaining local spending even when milk prices drop.
- Dairy is New Zealand's largest goods exporter by a significant margin, accounting for 35% of goods exports. Dairy generates $25.7bn of exports: 1 in 4 of every export dollar New Zealand earns.

Red meat sector's contribution to the New Zealand economy

The red meat sector's contribution to New Zealand's economic and social wellbeing was last calculated in 2020 by Economic and Policy consultants SG Heilbron. The report is also attached in Appendix 2B.

It found that the sector created:

- 92,000 jobs
- $12b in industry value added
- $4.6b in household income
- 4.7% of total national employment
- 10% of the regional economy and employment of Taranaki, Manawatu / Whanganui
- 12% of the regional economy and employment of Otago and Southland

Cost of offshore mitigation

A failure to consider warming impacts in target setting can lead to unrealistic mitigation goals. When these cannot be met through domestic mitigation efforts, New Zealand will be required to buy offshore offsets to address the shortfall. Not only is this an inefficient use of resources, but it delays New Zealand's transition to a lower emissions economy.

Domestic policy decisions (and corresponding investment) will materially influence the amount of domestic mitigation New Zealand is able to achieve and at what cost. In turn, this influences the volume of offshore mitigation that New Zealand may need to purchase to achieve the NDC.

Treasury reports that the cost of purchasing offshore mitigation to achieve New Zealand's NDC1 presents a significant fiscal risk for New Zealand. In the first Emissions Reduction Plan the Government stated that "achieving [the NDC] will also require some offshore mitigation". In 2022, the Climate Change Commission estimated that if the Government achieves its first and second domestic emissions budgets, 99 Mt CO_2e of offshore mitigation will still be needed to meet the NDC[14].

Treasury has estimated this as costing anywhere between $3,300,000,000 to $23,700,000,000[15] - described as "a significant fiscal risk". However, the Commission has stated that its advice to Government on the second emissions period will focus on New Zealand's domestic targets and actions to achieve them rather than its international commitments and how they might be met.

An order of magnitude difference between the Government's expenditure to reduce domestic emissions and the direct and indirect cost to the economy of purchasing international offset units does not serve New Zealand taxpayers well. The Commission should provide clear advice to the Government in this regard.

[14] NZ ETS settings for 2023-2027 (climatecommission.govt.nz)
[15] Ngā Kōrero Āhuarangi Me Te Ōhanga Climate Economic and Fiscal Assessment 2023

Technological developments

While important investment is underway to address gaps in mitigation technologies and infrastructure available to lower emissions from the agricultural sector, commercially viable options available to farmers remain very limited and do not match the assumptions made at the time the current targets were set. This ongoing unavailability of on-farm mitigation technologies presents a significant obstacle for farmers to achieve the legislated 2030 and 2050 target for biogenic methane.

Targets must consider the realities of mitigation technologies available to farmers. If these technologies are not widely available then meeting the current legislated targets can only be achieved through significant reductions in livestock production, which unnecessarily puts the New Zealand economy at risk.

The Report of the Biological Emissions Reference Group (BERG) (2018) stated that a methane inhibitor able to feed to dairy cattle in 2020 was "High Confidence". This is yet to be available. This represents a clear change in "Technological Developments" from those assumed when the 2050 target was legislated.

Table 3: The likelihood of two potential future mitigation options

Mitigation	Likelihood	Possible mitigation potential
Methane vaccine	Low confidence that it will be available by 2030 Medium-high confidence by 2050	30% reduction possible in both 2030 and 2050
Methane inhibitor	In-shed feeding (twice a day): • High confidence that it will be available by 2020[15]	5% efficacy in 2020, rising to 30% by 2030
	Extensive grazing systems (slow-release): • Medium-high confidence it will be available by 2025 • High confidence by 2050	10-30% efficacy in 2030, rising to 30-50% by 2050

The 2023 Biological Emissions Reduction Science and Mātauranga Plan (BERSA) acknowledges that successfully developing and commercialising new technologies is complex. New Zealand's pasture-based farm systems create unique challenges for mitigation solutions and their impacts within the farm system, including on the environment, animal health and welfare, and product quality and safety.[16]

[16] Biological Emissions Reduction Science and Matauranga Plan (BERSA)

Current methane mitigation options are limited to options that reduce total dry matter eaten. These can be summarised as:

- reducing total feed eaten by reducing supplementary feed use,
- reducing pasture growth by reducing use of nitrogen fertiliser, and
- Reducing pasture grown by converting land from pasture to forest.

Other interventions often cited, but that won't directly reduce emissions, are:

- Improving pasture and crop management to maximise dry matter yield and quality,
- Increasing the genetic merit of animals,
- improving animal health, longevity and reproductive performance.

Note that while these measures may improve the emissions efficiency of production, without a corresponding measure to reduce pasture production, they will lead to increases in production rather than reductions in emissions. The legislated biogenic methane target is a gross absolute target, not an intensity-based target. If a corresponding measure is applied to reduce production (such as less supplementary feed use), it is this corresponding measure that is actually reducing methane emissions. There is a risk of double-counting if both practices are assumed to be separate methods of reducing methane emissions.

We also encourage the Commission to note how technology can be recorded for emissions reductions. MPI have guidance on the pathway for emissions technology but it takes time. There needs to be research demonstrating technology relevant for New Zealand-specific conditions and pathways in place for capturing data of the national use.

We believe farmers should have a practical pathway for emissions technology used on-farm to be recognised in the National Inventory. BERSA recommended to support the continued development of the New Zealand Greenhouse gas inventory inclusive of new technologies, but it is an ongoing process. It is important to note that once technology is available it may take time for the emission reductions to come to be realised, depending on the technology type and the usage.

We are therefore supportive of Government and Industry:

- Continuing to co-invest in the development of the breakthrough technologies to support the agricultural sector to remain competitive, profitable, and sustainable;
- Creating a framework and protocol within the Hazardous Substances and New Organisms Act and the Agricultural Compounds and Veterinary Medicines regulations for new compounds and technologies to be imported, tested, manufactured and applied on-farm;

- Ensuring the processes in place through the CODEX system for new compounds and technologies are up-to-date to ensure that they will be accepted by New Zealand's key trading partners and within the domestic market;
- Undertaking case studies of different farms looking at the mitigations undertaken to meet the catchments nutrient limits and the effect on nitrous oxide and methane emission; and
- Implementing processes to ensure the National Greenhouse Gas Inventory can account for new mitigation options and technologies as they emerge.

The principal risks and uncertainties associated with emissions reductions and removals

The science is clear that gross reductions of gases are required to achieve and sustain net zero emissions. Greater definition is needed on the roles of gross emissions reductions and carbon removals in meeting the 2050 net zero target for long-lived gases. However, we consider a particular emphasis needs to be placed on reduction of carbon dioxide emissions.

Carbon dioxide dominates not only the overall level of global warming, but also the speed of that warming. In 2021, it contributed 45% of New Zealand's emissions profile compared to 10% from nitrous oxide. The agriculture sector currently has no feasible means to fully avoid nitrous oxide emissions from food production. Although farmers are already achieving reductions[17], they will eventually reach a point with fertiliser use beyond which further reductions would compromise food production. To avoid unintended consequences, further thought to a strategy for Nitrous Oxide, including technological advancements, from food production will be required.

We agree with the Commission's assessment that the current ETS structure creates a high risk that ETS-driven afforestation will continue to displace gross emissions reductions. We support work to amend the ETS to remove the distorting incentives for the blanket afforestation of productive farmland.

The environmental, social, cultural, and economic impacts of such large-scale land use conversion are significant for communities. We were pleased to see the Government acknowledge this in in its June 2023 announcements to potential reform the ETS and amend the National Environmental Standards for Plantation Forestry.

We support the principle of 'right tree, right place, for the right purpose'. We endorse an integrated landscape approach, where farmers are empowered to align appropriate land use with the appropriate land type, and natural resources are efficiently utilised within environmental limits. Integrated vegetation within farming systems has many co-

[17] As evidenced by the 9.5% drop in emissions associated with synthetic nitrogen fertiliser from 2020- 2021. For more, see New Zealand's Greenhouse Gas Inventory 1990-2021.

benefits. Poorly designed policy settings can drive land use change that brings negative outcomes and unintended consequences for rural communities.

The role of forests in climate policy, both indigenous and exotic, must be more clearly articulated and should consider other forest outcomes besides carbon removals. We also note the important role that forests will have in offsetting nitrous oxide emissions from food production, given there are currently no feasible means to fully avoid them.

Social, cultural, environmental and ecological circumstances

We encourage the Climate Change Commission to ensure that target setting fully considers the "rural proofing" framework to assess the challenges and social costs faced by rural New Zealand in responding to climate change.[18]

We also refer to the economic impact evidence which highlights the dependency of rural economies, the Māori economy, and communities on a thriving agricultural sector. This evidence shows that an inequitable approach to target setting without regard to the warming impacts of targets for different sectors risks undermining the social and cultural foundations of these communities.

[18] Rural Proofing Guide for policy development and service delivery planning (mpi.govt.nz)

5R Review of inclusion of emissions from international shipping and aviation in 2050 target

We recommend that New Zealand does not include international shipping and aviation in its 2050 target. Excluding emissions from international aviation and shipping from New Zealand's domestic emissions reduction targets recognises the global nature of these industries, adheres to international agreements, mitigates the risk of undermining the movement of people and goods, maintains economic viability, and acknowledges the unique technological and operational challenges these sectors face in reducing emissions.

International Agreements

Parties to the United Nations Framework Convention on Climate Change 1992 (UNFCCC) commit to adopting "*national policies and take corresponding measures on the mitigation of climate change*." The UNFCCC also states "*Parties should cooperate to promote a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties*" but that "*Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade*."

While most greenhouse gas emissions occur within national borders, in 2022 around 2% of global emissions occurred from international shipping and a further 2% from international aviation.[19] While a small percentage of global emissions, if not tackled, these greenhouse gas emissions could prevent the globe achieving international climate change targets. Countries have discussed this issue for 30 years now in multilateral processes. Under the Kyoto Protocol (1998) Parties agreed,

> *"The Parties included in Annex I shall pursue limitation or reduction of emissions of greenhouse gases not controlled by the Montreal Protocol from aviation and marine bunker fuels, working through the International Civil Aviation Organization and the International Maritime Organization, respectively."*

Note that, despite not having specific emissions reduction commitments for the period post-2020, New Zealand remains an Annex 1 Party to the Protocol and achieving our obligations under the Kyoto Protocol remains in the Purpose section of the Climate Change Response Act.

New Zealand is a signatory to international agreements that address emissions from aviation and shipping, such as the International Maritime Organization (IMO) and the International Civil Aviation Organization (ICAO). These organisations are responsible for setting global emission reduction targets for their respective industries.

[19] International Energy Agency. See here: https://www.iea.org/energy-system/transport/international-shipping and here: https://www.iea.org/energy-system/transport/aviation

International Maritime Organization

The International Maritime Organization (IMO) adopted its first set of mandatory measures to improve ships energy efficiency in 2011. These targets have been updated with enhanced ambition since 2011.

Very recently, at the IMO's Marine Environment Protection Committee (MEPC) 80th meeting, IMO members adopted further enhanced targets.[20] These include:

- Reduce the emissions intensity of shipping by 40% by 2030.
- Achieve 5% of the international shipping fleet operating on zero or near-zero emissions technologies.
- To peak GHG from international shipping as soon as possible and to reach net-zero GHG emissions by around 2050.
- Indicative checkpoints of: 20% reduction in international shipping emissions by 2030; 70% reduction in international shipping emissions by 2040.

International Civil Aviation Organization

The 41st ICAO Assembly adopted a long-term global aspirational goal (LTAG) for international aviation of net-zero carbon emissions by 2050 in support of the UNFCCC Paris Agreement's temperature goal.[21]

Importance of international trade and movement of people

International shipping and aviation play a key function in facilitating international trade and the movement of people.

Trade as a share of GDP has risen from slightly less than a quarter in 1970 to slightly over half of global GDP today. Over this time the portion of the world living in extreme poverty has fallen from around 50% in 1966 to under 10% today.

Likewise, the movement of people plays a key role in global economic and social development. Over a quarter of New Zealand's population were born overseas. New Zealand would be very different economically and socially without this flow of people.

Measures that aim to reduce direct emissions from international shipping and aviation need to be careful to not inadvertently hamper the global effort to combat climate change by increasing poverty or reducing the benefits of movement of people.

New Zealand's economy depends on international trade, which relies heavily on international aviation and shipping. Applying domestic targets to these sectors may

[20] See the revised strategy here: https://wwwcdn.imo.org/localresources/en/MediaCentre/PressBriefings/Documents/Clean%20version%20of%20Annex%201.pdf

[21] See here: https://www.icao.int/environmental-protection/Documents/Assembly/Resolution_A41-21_Climate_change.pdf

place an undue burden on the country's economy. Trade in agricultural products contributes significantly to New Zealand's GDP. Restricting international shipping could deter exports and harm farmers and growers who rely on this income.

International political risk

The politics of international trade are notoriously fraught. The Trade Openness Index shows global trade openness is now falling, off the back of the Covid-19 pandemic, for the first time since World War II.[22]

At this present time it is even more important that New Zealand be very cautious not to take actions needlessly that may further risk trade relationships. Measures that place restrictions or a price on international shipping and aviation into or out of New Zealand could be viewed by trade partners as a disguised barrier to trade.

Technological and Operational Constraints

Unlike some domestic sectors, international aviation and shipping have limited alternatives for reducing emissions in the short term. The development and deployment of low-emission technologies and fuels in these industries face substantial challenges.

Way forward for New Zealand

International shipping and aviation emissions do not occur in New Zealand. New Zealand is a Party to the UNFCCC and this agreement requires that we don't take unilateral measures that "constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."

New Zealand is a member of the IMO and ICAO, both of which are presently undertaking multilateral approaches to reducing international emissions.

We recommend that New Zealand does not include international emissions in our national climate change policies.

[22] Peterson Institute for International Economics. https://www.piie.com/research/piie-charts/globalization-retreat-first-time-second-world-war

Appendix 1: Agriculture emissions and warming in Aotearoa New Zealand to 2050: Insights from the science

Agriculture emissions and warming in Aotearoa New Zealand to 2050: Insights from the science

Miyabi Barth, Jessica Zionts, Michelle Cain, and Myles Allen

Funded by Beef + Lamb NZ, Dairy NZ, Federated Farmers

Executive Summary

This working paper discusses the concept of net zero emissions and what it means in the context of the warming from methane. Aotearoa New Zealand has set targets of achieving net zero emissions of carbon dioxide (CO_2) and nitrous oxide (N_2O) by 2050 and to reduce biogenic methane (CH_4) emissions by 10% by 2030 and 24-47% by 2050. This paper assesses the methane targets to 2050 under the Climate Change Response (Zero Carbon) Amendment Act of 2019 (CCRA) in Aotearoa New Zealand and provides analysis of what these targets, if achieved, would mean for the New Zealand economy's overall contribution to global warming. The purpose of this paper is to facilitate discussion among the public, government, and Climate Change Commission on the role of agricultural methane in New Zealand's mitigation strategy.

The scientific context is the very different manner by which methane, as a short-lived climate pollutant, affects global temperatures relative to the cumulative pollutants carbon dioxide and nitrous oxide. This science is very well understood. To stop carbon dioxide and nitrous oxide emissions from causing additional global warming, it is necessary to reduce the ongoing rate of emissions of these gases to net zero. Much smaller reductions, in the range of 10-30% over 30 years depending on prior methane emissions and ongoing emissions elsewhere, would stop methane emissions from causing additional global warming. Faster reductions in methane emissions can compensate for additional warming caused by other gases, while any increase in methane emissions has a disproportionately large additional warming impact. This very different response to methane emission reductions results from methane's relatively short, 12-year, lifetime and the fact that atmospheric methane concentrations are already elevated as a consequence of past and ongoing emissions.

A discussion of sectoral responsibilities to meet New Zealand's climate goals could be informed by contributions from respective sectors to past and ongoing global warming; to future additional warming under different scenarios; and the capacity of different sectors to reduce emissions. The decision on how much weight, if any, to give these three factors is a political one: the purpose of this report is simply to inform the first two.

Our analysis found that a 47% reduction in methane emissions by 2050, following a 10% reduction in methane emissions between 2020 and 2030, combined with linear reductions to net zero in CO_2 and N_2O emissions from 2020 to 2050, would see methane reductions essentially offsetting all future additional warming by CO_2 and N_2O emissions, bringing New Zealand's economy-wide cumulative warming back to 2022 levels by 2050. In this pathway, New Zealand causes net zero warming between 2022 and 2050 as the additional warming after 2022 is reversed by 2050. This is because the "cooling" impact of ambitious emission reductions in the agriculture and waste sectors compensates for ongoing additional warming caused by energy and transport emissions over this period. This compensation for the warming impact of fossil-based emissions by mitigation in the agriculture sector raises concerns of fairness and equity, considering the cumulative nature of CO_2 and N_2O emissions. Such concerns cannot be addressed solely through a scientific analysis of the impact of emissions, but would also need to account, inter alia, with the social, economic and other environmental impacts of emission reduction measures in different sectors.

Our analysis also found that a 24% reduction in methane emissions by 2050 combined with linear reductions to net zero in CO_2 and N_2O to net zero by 2050 from 2020 would see New Zealand achieve net zero additional warming as an economy between 2027 and 2050, assuming the rest of the world pursues current policies up to that time. Faster emission reductions would be required by New Zealand to achieve net zero additional economy-wide warming by 2050 if the rest of the world reduces emissions faster because New Zealand's emissions would then have a slightly larger absolute impact.

In both cases, New Zealand's total contribution to global warming would peak in the mid- to late-2030s thanks to the combination of CO_2, N_2O and methane reductions. Many developed countries have pledged to achieve net zero by 2050 at the latest. In countries where CO_2 is the dominant contributor to warming, which is the majority, this implies their total contribution to global warming peaks around 2050.

Reductions in all three gases are essential to achieve this peak in the 2030s, and varying the rate of methane reductions after 2030 has little impact on the level and timing of this peak assuming CO_2 and N_2O decline to net zero by 2050 as planned. Faster methane reductions after 2030 primarily affect the rate at which New Zealand's emissions contribute to reduce New Zealand's contribution to additional global warming ("additional cooling") in the 2040s and beyond.

Using a range of climate mitigation pathways for the rest of the world (i.e. depending on how quickly other countries reduce their emissions), we found that reductions in agricultural methane in the range of 15-27% between 2020 and 2050 would see agricultural methane in New Zealand alone contribute net zero additional warming relative to a 2020 baseline (i.e. no additional methane-induced warming from 2020 from the agricultural sector). We also assessed the mitigation potential of decreases in emissions across all greenhouse gases in the agriculture sector. If each gas were to be addressed separately, long-lived gases (CO_2 and N_2O) would both have to achieve negative emissions to counteract its additional warming since 2020, whereas methane would only require a relatively small (15-27%) cut.

Additionally, it is necessary to consider New Zealand's role as an agricultural exporter and as an efficient producer of food (Wirsenius et al. 2020). If methane targets are met by reducing agricultural output, this would increase pressure to convert land elsewhere in the world to make up for the lost production. Therefore, interventions should consider this opportunity cost of land, which places value on land that is already in agricultural production. In other words, if New Zealand reduces output, there would be more pressure to convert land elsewhere, and global emissions may not be reduced. Hence interventions should consider whether or not global methane emissions would decline as a result of declines in New Zealand's emissions.

Agricultural methane reductions beyond what is needed to eliminate further additional methane-induced warming can counterbalance the additional warming due to other gases and sectors, or compensate for agricultural methane's contribution to warming prior to 2020. However, the costs and impacts of this approach need to be adequately assessed, especially as compared to the costs and impacts of long-lived gas emissions reductions. Cost-benefit comparisons of different measures need to consider their impact on additional warming: treating methane as CO_2-equivalent using GWP_{100} (for example, under an ETS) can be misleading because it does not reflect the actual warming impact of either ongoing methane emissions or methane reductions.

This report finds that aggregate emissions using GWP_{100} provide a poor indicator of contributions to the achievement of a global temperature goal. Contributions to warming (either computed explicitly with a climate model or based on aggregate emissions using GWP*) are more directly relevant to the long-term temperature goal of the Paris Agreement, but nevertheless, a broad range of methane emission reduction targets are still consistent with different assumptions about the allocation of shares of future warming.

The decision to set a separate national target for methane emissions, informed by the impact of different gases on global temperature, rather than a target for aggregate emissions using GWP_{100}, is strongly supported by all available science and should be reflected in implementation measures. In this regard, Aotearoa New Zealand can and should provide an example of science-based climate policy for countries with significant agricultural methane emissions from livestock or rice production.

1 Background

Under the United Nations Framework Convention on Climate Change (UNFCCC) emissions accounting systems, agriculture in Aotearoa New Zealand accounts for 50% of national greenhouse gas emissions, with about half of the country's land area being used for agriculture according to the Food and Agriculture Organisation (FAO) (NZ MFE 2022). With the establishment of the NZ Zero Carbon Act in 2019, which sets forth an ambitious strategy for reducing national emissions, the extent to which agriculture is responsible for contributing to this strategy has been called into question. This is due to the fact that a large proportion of NZ's agricultural emissions are from ruminant methane, a short-lived climate pollutant (SLCP), which only persists in the atmosphere for around 12 years as opposed to the millennial timescale of carbon dioxide.

Developments in greenhouse gas accounting have shown that metrics that account for this short-lived property of methane can be used to more accurately predict the impact of today's emissions on future temperatures. This report uses modelling of national contribution to warming by industrial sector to explore the implications of targets set under NZ's Zero Carbon Act for the path forward for agriculture in Aotearoa New Zealand.

1.1 Explanation of Greenhouse Gas Metrics

Anthropogenic greenhouse gas (GHG) emissions drive increased average global temperature by altering the energy balance of the atmosphere (Houghton 2001). The 1997 Kyoto Protocol standardized national emissions reporting by applying the Global Warming Potential (GWP) metric over a 100-year time horizon so that greenhouse gases with different physical properties could be combined under a common unit (UNFCCC 1997). GWP values are calculated as the radiative forcing of a pulse of a non-CO_2 GHG over a designated time horizon relative to that of a pulse of carbon dioxide (Lashof and Ahuja 1990). The resulting values are thus dependent on the selected time horizon, which are most typically reported over 100 or 20 years with vastly different results for gases with lifetimes that are less than the time horizon of the metric.

Concerns regarding the use of GWP date back to the first IPCC Assessment Report in 1990, citing uncertainty in the calculations (IPCC, 1992). Calculating GWP over 100 years distorts the near-term impacts of short-lived GHGs (namely, methane). Conversely, reporting the 20-year GWP may incentivize the reduction of methane at the expense of carbon dioxide mitigation, when the quantities of both greenhouse gases must decrease (Climate Analytics 2017).

Other metrics have attempted to address these issues. The Global Temperature Change Potential (GTP) converts radiative forcing of a non-CO_2 GHG into the effect on global average temperature at a specific time horizon for a pulse or sustained emission relative to that of carbon dioxide (Keith P. Shine et al. 2005; K. P Shine et al. 2007). Proponents of GTP argue that it is a more policy-relevant metric due to its connection to temperature targets (Abernethy and Jackson 2022). However, the GTP constants are still strongly dependent on the selected time-horizon and thus the arbitrariness that arises from that choice.

Research in emissions accounting metrics identify the short-lived properties of GHGs like methane as responsible for the distorted incentives that come with conventional metrics. This is because the amount of global warming caused by short-lived GHGs is largely driven by their annual emissions rate (i.e. the flow into the atmosphere of that gas). This contrasts with long lived GHGs like CO_2, as their contribution to global warming is dependent on the total cumulative emissions since pre-industrialisation (i.e. the stock of the gas in the atmosphere). GWP* is a 'flow-based' metric, which looks at the rate-of-change of short-lived GHG emissions, which contrasts with GWP and GTP which are both 'stock-based' (M. R. Allen et al. 2018; Smith, Cain, and Allen 2021).

GWP* has been shown to more accurately model the relationship between historical emissions and historical temperature change due to this consideration of flow. Table 1 below expands on the differences between long- and short-lived greenhouse gases. This distinction is further illustrated by Figure 1.

Table 1: How long-lived and short-lived greenhouse gases affect the climate differently

Long-lived: carbon dioxide and nitrous oxide	**Short-lived: methane**
Eliminating emissions maintains contribution to global warming at a steady level (the temperature change caused by CO_2 plateaus)	Eliminating emissions leads to temperature declining from a peak, as contribution to global warming is driven by methane emissions rate (temperature change caused by methane declines until nearly all past warming has been reversed)
A constant rate of emissions leads to increased levels of global warming year-on-year (temperature change caused by CO_2 increases)	A constant rate of methane emissions maintains a constant level of warming relative to the base year, to first order. Including second order effects based on the present day and near future, temperature will increase slowly, as the climate is slowly responding to past increases in methane emissions (temperature change caused by methane increases slowly)
Reducing emissions slows the rate of increase of global warming (temperature change caused by CO_2 increases)	Reducing emissions can maintain methane's contribution to global warming at a constant level, if reductions are approximately 3% over 10 years. Reducing emissions faster than this can reduce global warming from methane. (temperature change caused by methane stable or declines)

Considering the Paris Agreement's goal to limit warming to well below 2 degrees, using a metric that measures the contribution of each gas to warming relative to that threshold would constitute a helpful policy tool. However, the use of conventional stock-based metrics (GWP_{100}) is somewhat entrenched in national and global emissions accounting schemes, although the Paris Agreement does allow the use of additional metrics. An alternative way of achieving a similar goal is to report GHGs separately and set separate targets alongside their GWP conversions (M. R. Allen et al. 2022). This would allow tracking of an entity's contribution to warming in addition to progress towards targets set using aggregate stock-based metrics.

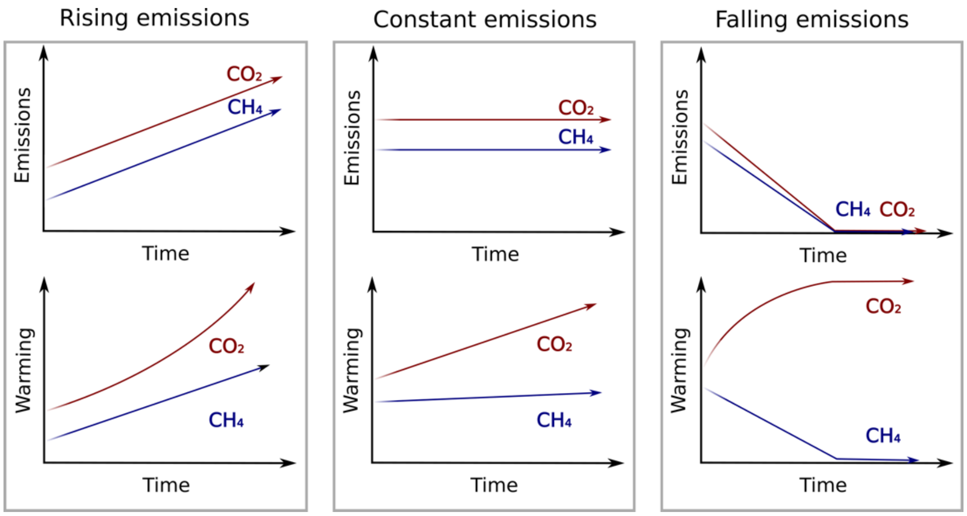

Figure 1: Figure from (M. Allen et al. 2022) showing the difference between the contribution to warming of methane and carbon dioxide under different emissions scenarios

1.2 Fossil versus biogenic methane and the carbon cycle

Due to the agricultural focus of this study, we must consider agriculture's role in the carbon cycle, as well as how the carbon in methane from the agricultural sector is distinct from that of carbon in fossil methane.

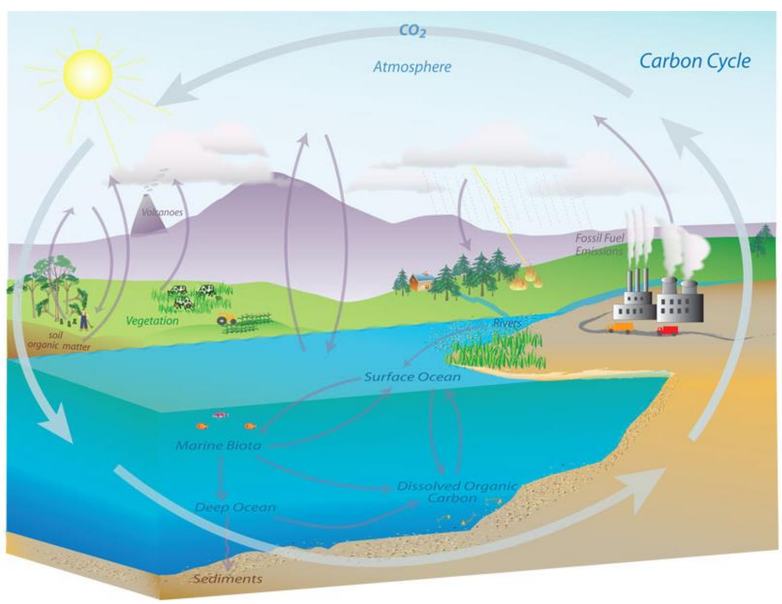

Figure 2: Simplified diagram of the carbon cycle https://www.noaa.gov/education/resource-collections/climate/carbon-cycle

The diagram of the carbon cycle (Figure 2) shows how carbon flows between the atmosphere, biosphere, ocean system, and earth's crust. These components of the carbon cycle occur on different timescales. Combustion of fossil fuels involves carbon that has been stored on a millennial timescale, whereas flows in and out of the biosphere occur on an annual or decadal timescale. It has been argued that this distinction must also be made when it comes to methane from fossil sources (i.e. natural gas) and biogenic sources (i.e. combustion of organic matter or enteric methane fermentation from livestock) (CLEAR 2020).

Approximately 12 years after methane is emitted into the atmosphere (on average), it oxidizes to form carbon dioxide and water. This carbon dioxide contributes to warming at a much lower level of radiative forcing than methane, but persists for centuries. For biogenic sources of methane, the carbon in the methane comes from atmospheric CO_2, and decays back to atmospheric CO_2. For fossil sources of methane, the carbon comes from fossil reserves, but is then added to the atmospheric stock of CO_2 once the methane has decayed. Thus, the contribution to warming for biogenic methane is marginally lower than that of fossil methane. This is accounted for in values for GWPs of methane, which are calculated for biogenic and fossil sources separately. For example, the IPCC AR6 value of GWP_{100} for fossil methane is 30, and for biogenic methane it is 27 (IPCC 2021b).

1.3 The Paris Agreement and Net Zero

Article 2 of the Paris Agreement states that countries must work to limit the "increase in temperatures to well below 2 degrees above pre-industrial limits and pursu[e] efforts to limit the temperature to 1.5 degrees." Article 4 states that in order to achieve the long-term temperature goal set out in Article 2, the world must "achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century," though the exact meaning of 'balance' is left undefined (UNFCCC 2015).

Balancing emissions and removals of carbon dioxide is possible because there are both anthropogenic sources and anthropogenic sinks of CO_2. However, the dissipation of methane from the atmosphere happens naturally on a decadal timescale. Terms like 'carbon neutral' or 'climate neutral' are possible definitions for 'balance.' Carbon neutrality means that all carbon emissions are balanced by removals, but does not include methane and nitrous oxide. Climate neutrality is similar to net-zero in that a company's actions have no net effect on the climate system, although definitions of what this means vary. Climate neutrality is defined in the AR6 glossary as "Concept of a state in which human activities result in no net effect on the climate system" (IPCC 2021a). If "effect" is interpreted as "additional global warming" this would correspond to a state of net zero warming-equivalent emissions such as calculated by GWP*, but other interpretation of "net effect" are possible. Noting these ambiguities, AR6 made limited use of the term climate neutrality.

Net zero GHG emissions is defined as a state in which greenhouse gases into the atmosphere are balanced by removals out of the atmosphere over a specified period (IPCC 2018; 2021a). This balance is defined using a metric of equivalence. As described in the previous section, measuring progress towards net-zero using a stock-based metric does not account for the fact that methane does not necessarily have to reach zero in order to reach balanced atmospheric levels. Likewise, stock-based metrics undervalue the significant temperature impact of increased rates of methane emissions.

It is well-known that global warming is most strongly correlated with cumulative carbon emissions (Matthews et al. 2009; Zickfeld et al. 2009). Therefore, reaching net-zero carbon is the primary determinant in whether emissions are balanced. In other words, reducing methane in lieu of reducing carbon does not address the issue of cumulative greenhouse gases. Because Article 4.1 references the temperature limit in Article 2, any definition of balance that is not guaranteed to achieve the temperature goal would create an inconsistency between the two articles. Thus, this paper analyses the impact of emissions with regards to their impact on the balance of greenhouse gases in the atmosphere and their impact on future temperatures.

1.4 Incorporating the cost of using land

Human material demands for land-based products such as food, feed, and fiber are major drivers of deforestation as well as the emissions from land use change, both historical and current. The 2019 World Resources Report: Creating a Sustainable Food Future highlights the need to include the carbon cost of using land for human purposes, also called the Carbon Opportunity Cost (COC) (Searchinger et al. 2019). This metric can be thought of as either the foregone sequestration due to human appropriation of land, or the average carbon cost to produce the next unit of a product globally. Products that require a large amount of land per kilogram of protein such as red meat and dairy have higher COCs. As demonstrated in a recent report applying this accounting framework to Danish agriculture, including the COC in national emissions calculations incentivizes more efficient production of food in order to alleviate pressure to deforest for food production elsewhere (Searchinger et al. 2021).

A recent report for the New Zealand Commissioner for the Environment estimates how much forestry would be required to offset warming from agricultural methane, and the area required was astoundingly high (PCE 2022). If this land area dedicated to forestry comes at the expense of agricultural output by taking land out of production, resulting in reduced output of milk and meat, this could drive land clearing elsewhere to meet demand. It is therefore important to consider these knock-on effects when developing a land sector strategy. The goals of agricultural mitigation decision-making should focus on how to produce more food on less land while reducing greenhouse gas impacts. One way to incorporate this concept into farm-level emissions accounting would be to set and track intensity targets for both land and emissions per kilogram of protein (see section 1.7 for further detail). Global food demands are projected to significantly increase between now and 2050, so in order to prevent conversion of natural ecosystems, existing productive land must become even more productive (Searchinger et al. 2021).

1.5 International agriculture and emissions policies

In the wake of the Paris Agreement and its temperature limits, countries and companies alike have set net-zero targets, and some have laid out plans for how they intend to achieve them.

However, the Zero Carbon Act puts forward that biogenic methane should have a separate target due to its decadal lifetime (Ministry for the Environment 2019). This is based on previous research and IPCC scenarios that found that biogenic methane does not need to reach net-zero in the same way that is required of carbon dioxide to halt the increase in global average temperature (Rogelj et al. 2018).

The UK, for example, passed the Climate Change Act in 2008, which mandates national net-zero emissions by 2050 relative to 1990. However, their land use policies do not necessarily indicate the separation of GHGs in target setting (Committee on Climate Change 2020). Their proposed interventions instead focus on planting trees and sequestering carbon in agricultural soils, both of which have dubious additional climate benefits due to the competition for land use (Ranganathan et al. 2020).

Meanwhile, the European Union's 'Fit for 55' plan, which requires a reduction of GHGs of 55% by 2030, makes no mention of reducing agricultural emissions at all (European Council 2023). However, some countries within the EU have published their own strategies. For example, Ireland's 2021 Climate Action Plan outlines a plan to reduce agricultural emissions by 30% by 2030, though their plan does not set separate targets by GHG (Government of Ireland 2021). It's important to note that Ireland has a simultaneous target to increase their dairy herd, milk output, and land dedicated to agriculture, a strategy that may conflict with their emissions reduction targets (McDonnell 2020). Overall, it appears that very few countries, if any, have set a biogenic methane target aside from New Zealand. For example, India has 23% of world milk production and intends to increase its production by 6% per annum. India's current carbon footprint per litre of milk is around 3 times that of New Zealand. A recent report (Mazzetto, Falconer, and Ledgard 2022) ranked New Zealand is the most efficient producer of fat and protein corrected milk (FPCM) – 46 percent less than the average of the countries studied.

Beyond national emissions targets, the Global Methane Pledge run by the Climate and Clean Air Coalition is an agreement by signatories to collectively work together to reduce anthropogenic emissions by 30% by 2030 relative to 2020 levels. While this global pledge is not specific to biogenic methane, over one hundred countries have signed, implying that nuanced discourse on short-lived pollutants is happening around the world.

1.6 National emissions targets and emissions intensity targets

New Zealand's national emissions targets were written into law in 2019. The emissions target set out mandates net-zero GHGs by 2050, with the exception of biogenic methane, which must be reduced by 10% relative to 2017 levels by 2030 and by 24-47% relative to 2017 levels by 2050.

The targets were derived from the IPCC Special Report on 1.5 degrees, which acknowledged that methane behaves differentially in the atmosphere than long-lived GHGs and there should be separate targets for methane (IPCC 2018).

It was specifically noted in that report that these ranges should not be used directly by countries for their targets: “These pathways illustrate relative global differences in mitigation strategies, but do not represent central estimates, national strategies, and do not indicate requirements.” (IPCC 2018, Figure SPM3.b caption). Additionally, the New Zealand national emissions targets do not include the Carbon Opportunity Cost of land, meaning that any leakage from lost food production that might result from meeting the biogenic methane target would not be captured. As the SR1.5 emphasises, the most important point for meeting Paris Agreement goals is the impact of national policies on global emissions, so policies that simply displace emissions from country to country have limited impact.

Using conventional Global Warming Potential over a 100-year time horizon, agriculture is responsible for nearly half of New Zealand’s national annual CO_2-equivalent emissions, with the largest contribution coming from methane from livestock. However, agriculture is currently not responsible for half of the nation’s contribution to annual warming when we take into account methane’s shorter residence time in the atmosphere relative to carbon dioxide. This mismatch could lead to inadvertent biases if GWP_{100} is solely used to determine mitigation policy and hence modelling how emissions affect global warming is useful (Reisinger and Clark 2018). Their paper showed that agriculture caused about 10-12% of global CO_2-e (GWP_{100}) emissions in 2010, but modelling showed that direct livestock emissions of non-CO_2 GHGs led to 19% of the global warming at that time, rising to 23% if CO_2 from pasture conversions were included. The reason for the discrepancy is that global agricultural methane emissions had increased substantially over preceding decades, and conventional CO_2-e (GWP_{100}) understates the impact of these increases. This report will assess the contribution to warming of the New Zealand agriculture sector relative to other sectors, and the impact that would result from the percent reduction targets for biogenic methane.

While national emissions accounting remains a common approach, there is an ongoing discussion regarding the use of intensity metrics either instead of or in addition to gross emissions within a national boundary. Intensity metrics measure the emissions per unit of output (meat, milk, etc.). These values incentivise reduction of emissions without sacrificing the production of food. While national gross emissions targets are important, they can result in the “offshoring” of production emissions and land use if the incentivised strategy is to reduce agricultural production within the national boundary just to import it from somewhere else. This analysis addresses the contribution to warming and emissions reductions at a national scale, but as mitigation decisions are made, the impact should also be assessed from the perspective of the global emissions intensity to avoid perverse outcomes.

2. Contribution to warming of New Zealand agriculture

In this section, we analyse the contribution of different sectors and different greenhouse gases to global warming at present and in the future for different scenarios. The methods and models used are described in more detail in Appendix 1.

2.1 Sectoral contributions to global warming

Emissions of methane, carbon dioxide and nitrous oxide for each sector of the economy are shown in Figure 3 since 1990, showing that agriculture dominates methane and nitrous oxide, and energy dominates carbon dioxide emissions. These national inventory emissions, combined with a historical emissions dataset back to 1850 are used to drive a simple climate model, FaIR (Leach et al., 2021 and see Appendix 1 for methodology).

Figure 4 shows the contributions to global warming of each sector of New Zealand's economy since 1850. Methane is the dominant contributor to global warming when evaluated relative to this baseline, causing nearly 60% of New Zealand's contribution to global warming since 1850. Consideration of a pre-industrial baseline demonstrates the influence of the choice of base year on the results, but although the issue of "historical responsibility" is frequently raised in international climate discussions, high historical emitters such as the European Union have consistently opposed it being used to inform discussions of emission reduction targets. As such, contributions to additional warming since 1990, arguably the earliest date of an emerging international consensus on the climate issue, are more relevant.

New Zealand contributions to global warming by gas and sector since 1990 are shown in Figure 5, revealing that in the recent past, energy has caused considerably more global warming than agriculture. This demonstrates that when you choose a different baseline year to consider additional warming since, this can change which sector will have contributed the most to global warming. Table 2 shows the proportion that each sector contributes to global warming between 1990 and 2020, with energy contributing the largest proportion (54%) and agriculture second at 37% based on this model. (Methane was responsible for 16% and nitrous oxide 20% of the 37% contribution to warming from agriculture over this period.)

When aggregating GHG emissions to CO_2-e using the AR5 value of 28 for GWP100, agriculture represents 51% of the total CO_2-e emissions in 2020, giving it the largest sectoral emitter and which is a far greater proportion than its 37% contribution to additional warming since 1990.

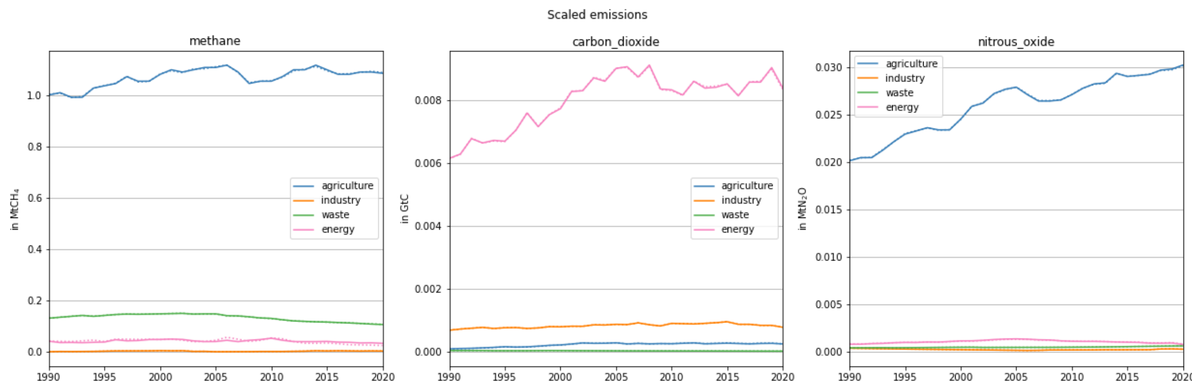

Figure 3: Emissions of CH_4, CO_2 and N_2O from agriculture in New Zealand

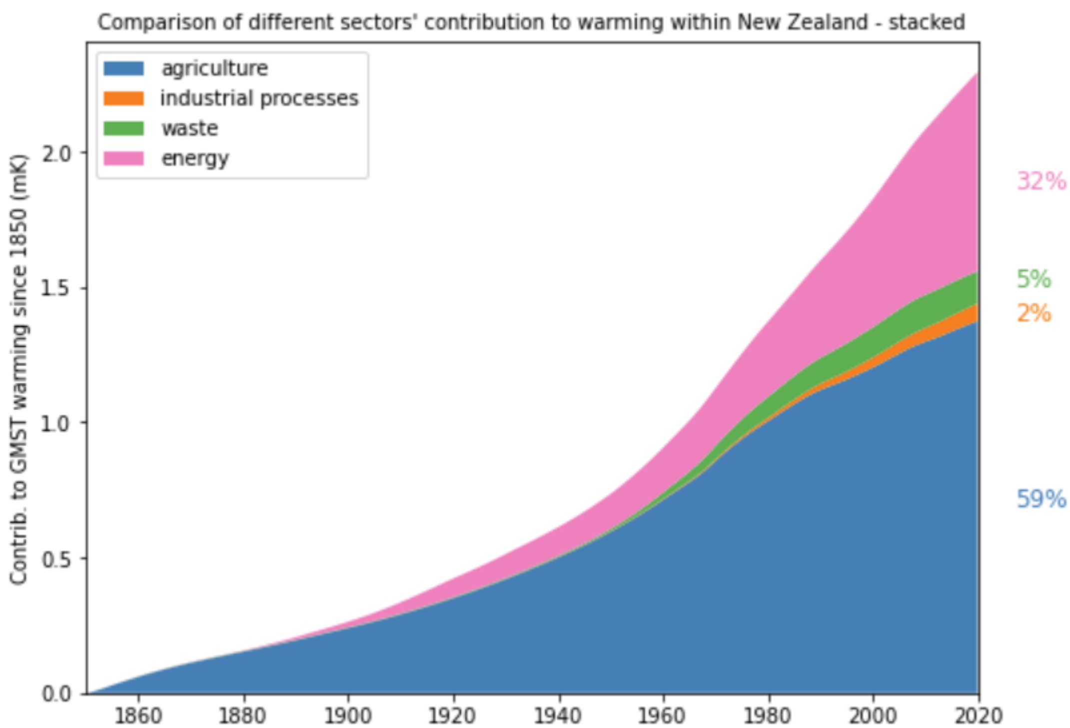

Figure 4: Contribution to additional global warming since 1850 from GHG emissions from each sector in the New Zealand economy. Emissions include CO_2, CH_4 and N_2O

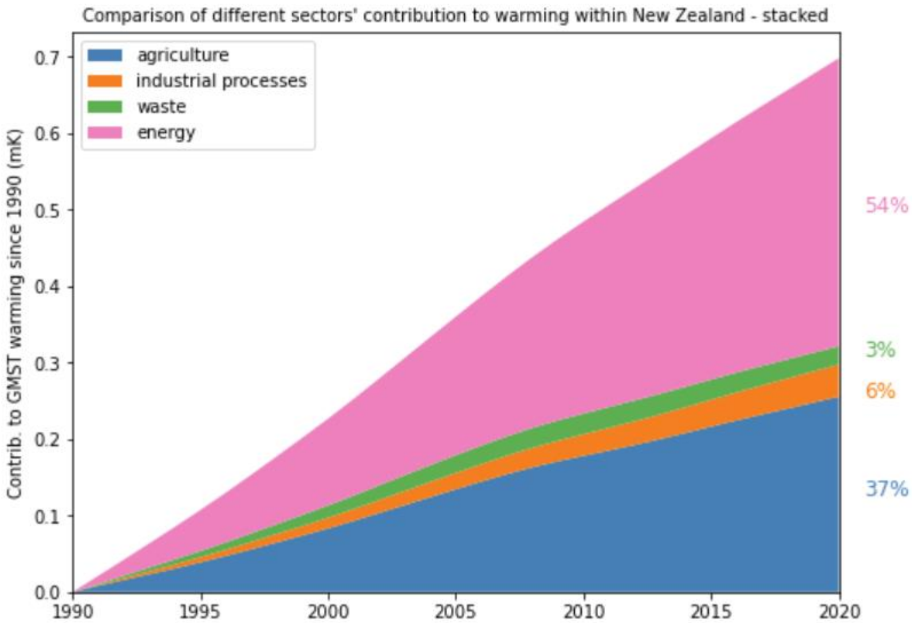

Figure 5: As figure 4, but with a baseline year of 1990.

Table 2: Contribution to additional warming by sector in New Zealand between 1990 and 2020

New Zealand Sector	Contribution to additional warming between 1990 and 2020
Agriculture	37%
Industrial Processes	6%
Waste	3%
Energy	54%

Next, we consider the contribution to warming from New Zealand's agricultural emissions in more detail. Virtually all greenhouse gas emissions in the agriculture sector are nitrous oxide and methane, with a small amount of carbon dioxide resulting from the use of fossil fuels for farm equipment. Nitrous oxide comes directly from manure management as well as direct and indirect emissions from applied nitrogen on fields. Methane also results from manure management as well as enteric fermentation of ruminants. Table 3 shows that, since 1990, methane is responsible for just over 40% of the warming from agriculture despite the fact that it is short-lived.

As methane is a short-lived pollutant, the rate at which its emissions increase temperature is largely driven by how rapidly methane emissions are increasing (M. R. Allen et al. 2018).

Between 1990 and around 2006, methane emissions were increasing; from 2006 onwards there is some variability, but the trend is relatively flat. This translates to a steeper gradient in the contribution to temperature from methane emissions (blue wedge in Figure 6) before 2006 and a reducing gradient thereafter.

For a few years around 2006, methane accounts for 50% of the warming from agriculture since 1990. From 2008 onwards, the proportion is less than half. For the other key agricultural GHG, N_2O, its long lifetime (over a century) means that the level of global warming it contributes over a period of several decades is largely driven by its cumulative emissions. Since 1990, New Zealand's emissions of N_2O have followed an increasing trend, and thus the amount of global warming from this gas continues to rise (green wedge in Figure 6). By 2015, N_2O contributes 50% of New Zealand agriculture's global warming since 1990, rising to 53% by 2020 (Table 3). Over time the proportion of global warming from agricultural CO_2 also increases, as it is long-lived and therefore has a cumulative effect on global warming. Appendix 2 provides a more detailed discussion of the differences in contribution to warming of long-lived and short-lived greenhouse gases in New Zealand and the significance of selecting a temporal boundary.

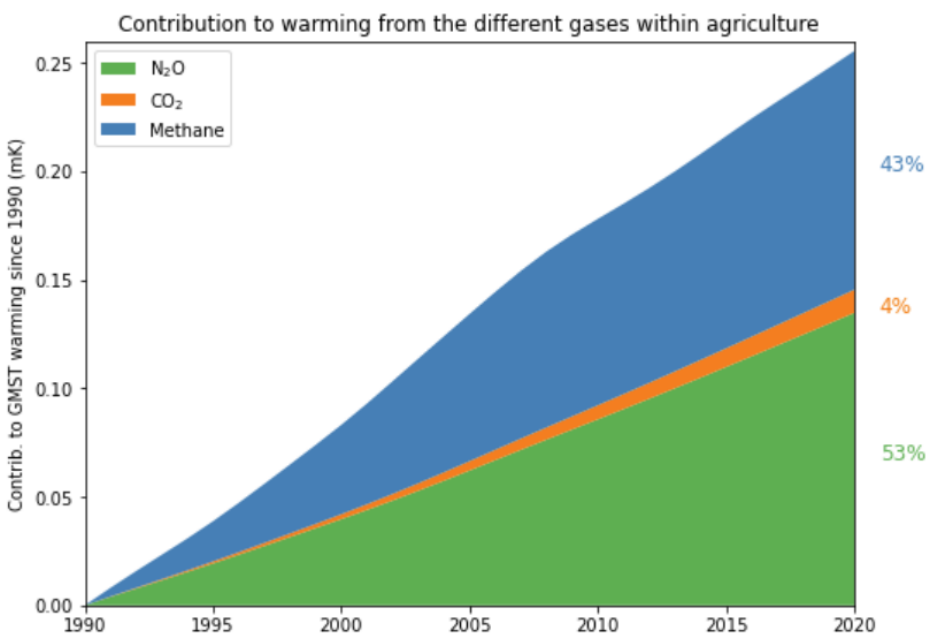

Figure 6: Contribution to additional warming since 1990 of CH_4, CO_2 and N_2O emissions from agriculture in New Zealand, based on the FaIR model.

Table 3: Contribution to additional warming in 2020 since 1990 for the agriculture sector by greenhouse gas

Gas	Contribution to additional warming in 2020 since 1990 within agriculture
CH_4	43%
CO_2	4%
N_2O	53%

Combining the information in Tables 2 and 3, agricultural methane emissions have therefore contributed approximately 16% (43% of agriculture's 37% contribution) of additional warming caused by all economic activity in New Zealand over the period 1990 to 2020.

3. Contribution to warming under New Zealand's Zero Carbon Act

New Zealand's Zero Carbon Act (ZCA) requires that, by 2050, all long-lived greenhouse gases reach net-zero, and biogenic methane reduces by 24-47% relative to 2017 levels, with a 10% reduction by 2030. The question of whether or not this target is aligned with the 1.5 degree Paris Agreement threshold, or indeed whether this target represents a fair distribution of responsibility across New Zealand's sectors, is not possible to answer solely based on physical science. The most universally-relevant target would be to simply say that all countries and industries have a responsibility to minimize their contribution to warming as much as possible. There is no scientifically agreed-upon method of disaggregating the responsibility further, and the level of mitigation of each country essentially depends on the actions taken by all others. However, we can look objectively at the impact that this target has on New Zealand's contribution to warming. We can then try to understand what actions are necessary to meet the target, and who should be responsible for implementation and supporting the transition.

It is useful to note that the methane reduction targets are gross, while the targets for the long-lived gases are net and rely on offsetting to be achieved.

Figure 7 shows the additional warming impact over time since 2020 if emissions are reduced linearly in line with the ZCA target, with the solid lines for methane and total warming representing 24% reduction for methane and the dotted lines representing 47%. This graph shows that New Zealand would achieve peak warming or "net zero additional warming" as an economy in the 2030s. The deeper methane cuts allow the country to effectively reverse all New Zealand's additional warming that has occurred since 2022.

In other words, reducing emissions in line with the more ambitious target would come close to the entire country achieving zero additional contribution to warming by mid-century relative to 2022, but would stop just shy of meeting that goal.

An important discussion is whether the policy priority should be limiting New Zealand's peak contribution to warming, or contribution to warming by 2050. The figures show that, if we assume that CO_2 and nitrous oxide are indeed reduced to net zero by 2050, the main impact of greater rates of methane reductions after 2030 is to achieve 'additional cooling' after New Zealand's overall contribution to warming peaks.

While the additional warming since 2020 from long lived gases will remain constant after they have reached net-zero emissions, New Zealand agriculture's methane emissions represents a mitigation opportunity for 'additional cooling' to counter the long-lived gases' 'additional warming'. In summary, the ZCA emissions cuts would lead to CO_2 and N_2O generating some additional warming between now and 2050, as their declining emissions over this time period cause additional warming (Table 1 and Figure 1).

One might interpret this result in such a way that New Zealand's agricultural emissions have the potential to be the deciding factor in whether or not the country achieves zero additional contribution to warming (see Figure 8 for additional warming from each sector). Assuming that every other sector pursues mitigation strategies that are as ambitious as possible to reach net-zero emissions, the New Zealand government should invest in mitigation of the agricultural sector as well, noting that it is the only sector with substantial potential to achieve additional cooling. However, the reduction of agricultural methane emissions should not come at the expense of food production. A recent report on mitigation in the Danish land sector projects that demand for food will grow significantly between 2010 and 2050 (Searchinger et al. 2021). The logic therefore follows that, on a global average, every hectare of productive agricultural land must produce significantly more food in order to avoid the conversion of natural ecosystems for agriculture elsewhere. The technologies required to reduce agricultural emissions, particularly methane, without impacting yields, are still very much nascent.

As the figures below demonstrate, the reduction of agricultural methane is an integral part of minimizing contribution to warming and therefore avoiding 1.5 degrees of warming globally. Thus, measures to reduce methane emissions intensities, e.g. enteric methane inhibitors, genetics, health improvements, etc. would be a substantial contribution to minimizing warming and protecting food security globally.

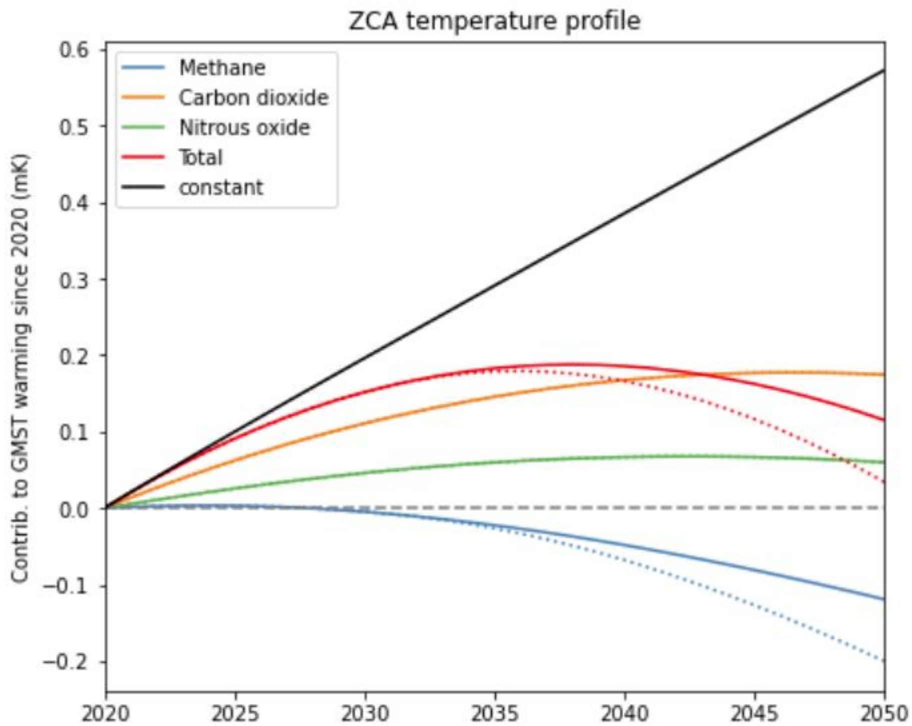

Figure 7: Additional warming since 2020 for ZCA emissions strategy (red)compared with potential additional warming that would occur if emissions continued at present-day levels (black). Solid lines for methane show a 24% reduction by 2050; dotted lines a 47% reduction by 2050. The background scenario used is SSP-245, a current policies scenario. The additional warming would be different under other background scenarios as this will affect the radiative efficiency of each gas.

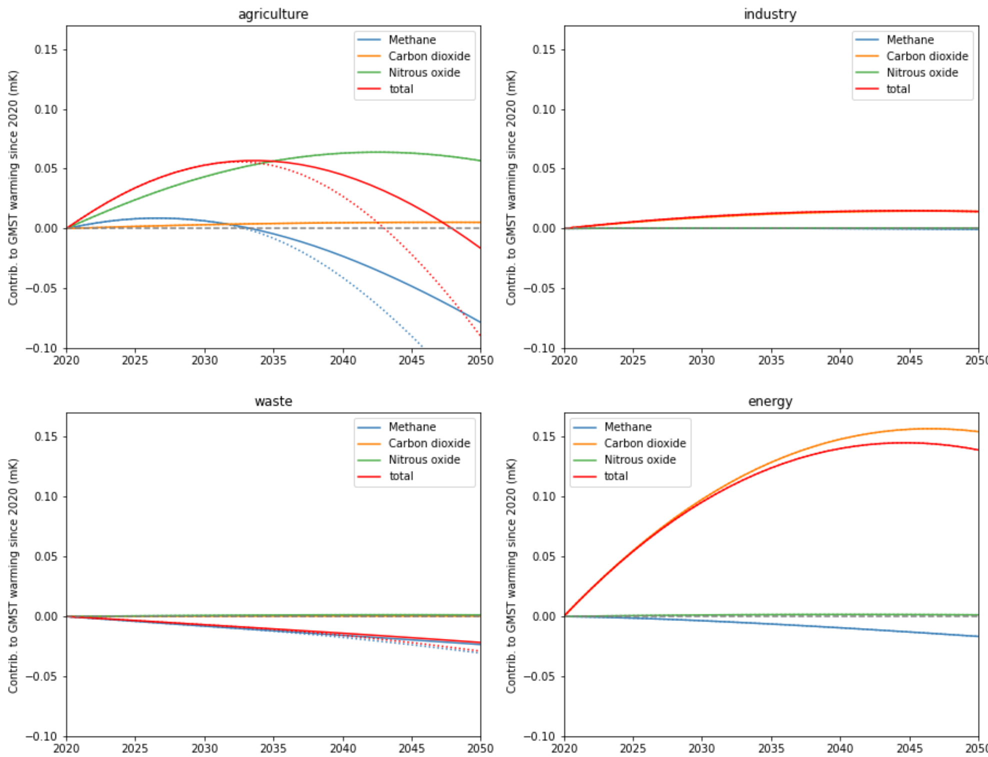

Figure 8: Additional warming under the ZCA broken down by greenhouse gas for agriculture (top left), industry (top right), waste (bottom left), and energy (bottom right)

4 Warming implications of different targets for 2050

4.1 Scenarios of equal additional warming

In this section, we consider the implications for global warming of different theoretical future emissions reductions for New Zealand, to gain insight into how much impact cutting each different gas has. In both of the following two examples, the same amount of additional warming has occurred in 2050 relative to 2020 from the long lived gases, and from methane.

Figure 9 shows an emissions pathway determined by the constraint that at 2050, the additional warming from each GHG relative to 2020 is zero. In other words, by 2050, the warming from each GHG is the same as it was in 2020. Methane reduces by 15% over the 2020 to 2050 period to generate this outcome, which is a lower level of reduction than stated in the Zero Carbon Act. CO_2 and N_2O emissions, on the other hand, must go net-negative halfway through the time period in order for the negative emissions to offset the emissions (and warming) in the first half of the period.

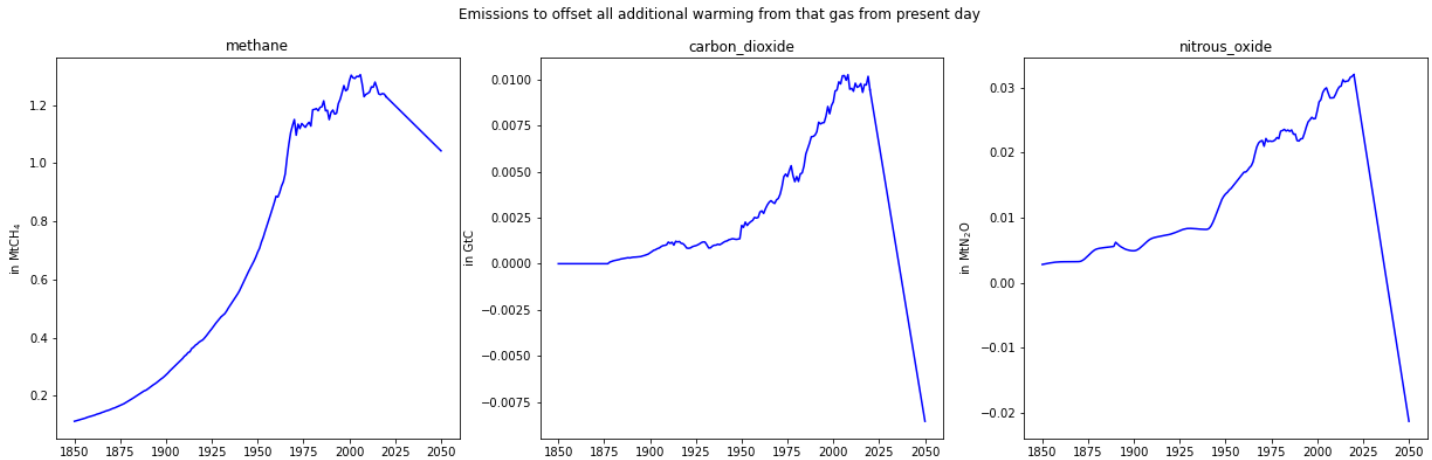

Figure 9: New Zealand's emissions of CH_4, CO_2 and N_2O in a scenario where the additional warming at 2050 relative to 2020 for each individual gas is zero

In the next experiment, we have considered first the warming impact of reducing CO_2 and N_2O emissions from New Zealand to zero by 2050, linearly. We have then calculated (method in Appendix 1) how New Zealand's methane emissions would need to change between 2020 and 2050 to give the same additional warming impact at 2050. As the CO_2 and N_2O emissions lead to additional warming over this period, this means that the CH_4 emissions would have to rise by 35% over this period to match the same level of additional warming. Figure 10 shows the additional warming since 2020 for this hypothetical scenario, where methane and long-lived gases (LLGs) reach the same level of additional warming at 2050. It is important to note that this experiment is purely theoretical and not a recommended course of action. Moreover, the trajectories are very different, with methane-induced warming under this scenario increasing monotonically while LLG-induced warming peaks and begins to decline. If the trends were to continue beyond 2050, the contribution to global warming from methane would exceed that from CO_2 and N_2O. This experiment only illustrates matching the warming at 2050.

These experiments demonstrate the differences between how long and short-lived gases affect temperature. Notably, reducing emissions of CO_2 and N_2O to zero does not eliminate the level of warming already caused by historical emissions. This is a key difference between methane and the LLGs, and why LLGs need to reach net-zero to stop additional global warming, whereas methane can be cut by a lesser fraction and lead to no additional warming – and possibly even additional cooling if emissions are cut by a large enough fraction.

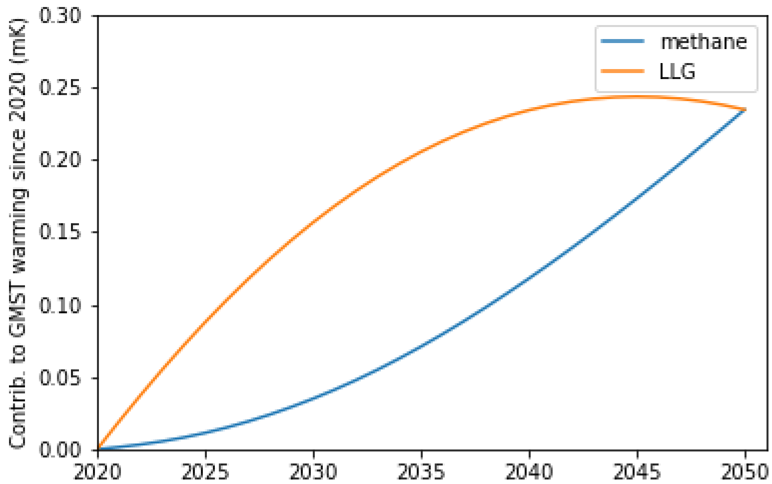

Figure 10: Additional warming since 2020 for the scenario where additional warming from methane is matched to be the same in 2050 as for long lived gases (LLG) which have linearly decreased to zero emissions in 2050 (for the whole New Zealand economy). This results in methane emissions rising by 35% between 2020 and 2050 in order to generate the same additional warming as the LLGs.

4.2 Reduction needed by the agriculture sector to eliminate additional warming

By assuming a linear decrease in methane emissions between 2020 and 2050, we found the percentage reduction in methane emissions that was required by 2050 to offset the warming from (a) agricultural methane emissions since 2020 and (b) all agricultural emissions since 2020 (i.e. CH_4, CO_2 and N_2O). This was calculated relative to two different background emissions scenarios: SSP-119 (a highly ambitious mitigation scenario) and SSP-245 (a moderate ambition scenario, see Appendix 1 for further details).

SSP-119 is a pathway to keeping global temperatures from rising 1.5 degrees above pre-industrial levels. SSP1 denotes the 'taking the green road narrative' and SSP-119 refers to a radiative forcing on 1.9 W/m^2 under SSP1. SSP-245 is a 'middle of the road' pathway (SSP2) to keeping global temperatures rise to less than 3 degrees above pre-industrial levels (4.5 W/m^2). SSP-245 can be thought of as the world continuing with business as usual without strengthening climate action, and therefore does not achieve the Paris Agreement goal of limiting warming to well below 2 degrees (Riahi et al. 2017; Meinshausen et al. 2020).

To provide context for these scenarios, if all countries that have made commitments under the Paris Agreement to reduce their emissions achieve their current targets it is estimated that this would keep global temperatures from rising 2.4 degrees above pre-industrial levels by the end of the century (Climate Action Tracker 2021).

To undo all the warming from New Zealand's agricultural CH_4 since 2020 by 2050, CH_4 would have to reduce by between 15-27% between 2020 and 2050, dependent on the background emissions scenario.

To undo all the warming from all agricultural emissions between 2020 and 2050, the CH_4 cuts would have to be between 29-40% (Table 4). It is useful to note that New Zealand already has a target to reduce nitrous oxide to net zero by 2050.

In the less ambitious scenario (SSP-245), there is a higher concentration of CH_4 in the atmosphere than the more ambitious scenario (SSP-119). As the radiative efficiency of CH_4 and N_2O is anti-correlated with its own atmospheric concentration (Reisinger, Meinshausen, and Manning 2011), each kg of CH_4 or N_2O emitted produces a smaller amount of warming in the less ambitious scenario. There is therefore a smaller amount of warming to offset using CH_4 cuts in SSP-245. Following this principle, the higher the background emissions scenario, the lower the percentage cuts would be, as the amount of warming generated from the same amount of emissions would be less.

Using GWP*, one would approximate 0.3% reductions per year (i.e. around 10% reduction between 2020 and 2050) to have no additional warming. However, there is an approximately 20-year lag after this cut is implemented before the temperature levels off, so there would be some additional warming between 2020 and 2040. Hence, if the scenario requires temperature to return to 2020 levels, a larger cut is required to do so, e.g. 15% in the SSP-245 background scenario, which is more similar to the background assumption for the standard GWP* equation (Smith et al., 2021) than SSP-119.

In the context of the ZCA targets, this model result means that a 24% reduction in CH_4 emissions by 2050 would offset all, or nearly all, of the additional warming from agricultural CH_4 emissions since 2020. A 47% reduction would offset more than all the additional warming from all agricultural emissions since 2020.

Table 4: Methane reduction relative to 2050 for various SSPs

	CH_4 reduction at 2050 relative to 2020 (%)	
Baseline emissions scenario	To offset warming from agricultural CH_4 since 2020	To offset warming from all agricultural emissions since 2020
SSP-119	27	40
SSP-245	15	29
SSP-370	8	23

4.3 Change in methane needed to be consistent with a target of limiting global warming to 1.5 degrees

It is important to note there is yet no agreed simple formula to determine individual country's responsibility and capability. It is also beyond the scope of this paper to provide commentary on which of the potential methods is most appropriate. However, some of the potential methods put forward for assessing country responsibility are impacted by the use of the GWP_{100} metric and would provide different results if a warming-based approach is used. In particular, emissions per capita is often put forward as a method of determining country responsibility. Any allocation of "fair shares" of mitigation contributions requires decisions on what is being allocated and the basis for the allocation.

National historical contributions to warming to date are generally much closer to national fractions of current consumption or GDP than fractions of the global population. This reflects the fact that, in general, resources are typically allocated in terms of ability to pay rather than on an equal per capita basis. There is no global resource that is allocated on an equal per capita basis, so allocating contributions to future emissions, total warming, or additional future warming, on an equal per capita basis would represent a significant policy innovation. Most scenarios indicate national contributions to future warming continue to reflect GDP more than population.

Whatever approach is used, a stock-based metric, like GWP_{100}, does not accurately reflect the relationship between a country's emissions and their contribution to additional warming. New Zealand's current percentage contribution to ongoing global warming and New Zealand's current percentage of global emissions aggregated using GWP_{100} differ by more than a factor of two, and the discrepancy would be even greater if emissions were aggregated using GWP_{20}. This demonstrates how misleading emissions aggregated using any standard metric can be in evaluating contributions towards achieving a global temperature goal. As stated in Reisinger and Clark (2018) "Evaluating the effects of direct livestock emissions on actual warming without relying on any simplifying GHG equivalence metric is therefore highly desirable to inform robust mitigation choices."

Figure 11 shows, purely as an illustration, that if CO_2 and nitrous oxide emissions were reduced linearly to net zero over 2020-2050, then limiting New Zealand's contribution to additional warming from 2015 to 0.065% of 0.4°C (i.e. a contribution to post-2015 warming consistent with reaching 1.5°C in 2050 and New Zealand's share of the global population, ignoring contributions to warming prior to 2015) would require methane emissions to be reduced by 27% over this same period. Although the allocation of responsibility for emission reductions according to historical contributions to warming has been extensively discussed in UNFCCC negotiations, there has been no consensus on either how historical responsibility should be calculated or how if at all, it should be taken into account in setting targets.

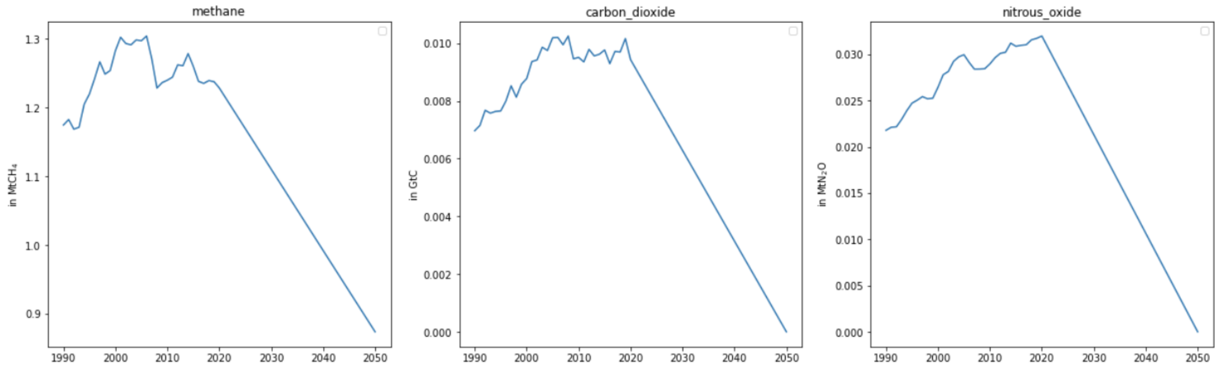

Figure 11: Emissions reductions under a 'fair-share per capita' scenario relative to 2015.

In summary, aggregate emissions using GWP_{100} provide a poor indicator of contributions to the achievement of a global temperature goal. Contributions to warming (or aggregate emissions using GWP*) are more directly relevant to the long-term temperature goal of the Paris Agreement, but nevertheless, a broad range of methane emission reduction targets are still consistent with different assumptions about the allocation of shares of future warming.

Appendix 1: Methods

For the emissions calculations, we employed two datasets; historical PRIMAP emissions data extending back to 1850 and New Zealand's Greenhouse Gas Inventory data spanning the years 1990 to 2020. Our preference was to use the official inventory data but due to its lack of historical data, we scaled the PRIMAP data from 1990 to 2020 to fit the inventory data. This was achieved by taking the ratio of the mean values of the inventory and PRIMAP data between 1990 and 2020, subsequently applying this ratio to the entirety of the PRIMAP dataset from 1850. Our analysis concentrated on the three primary greenhouse gases: methane, carbon dioxide and nitrous oxide. To accurately convert emissions profiles into warming, we used the emissions data in the gases' native units as inputs into a simple climate model called the Finite-Amplitude Impulse Response model (FAIR).

In order to calculate warming, we first established an emissions baseline. Shared Socioeconomic Pathways (SSPs) represent scenarios of projected socioeconomic shifts, each accompanied by a corresponding emissions trajectory. SSP-245 is a middle of the road mitigation scenario, perhaps representative of the current policy outlook, where warming in 2100 is around 2.8◦C (Meinshausen et al. 2020). We examined the temperature difference between the baseline emission (SSP-245) and the baseline emissions minus the emissions of interest, thereby determining the warming attributable to the specific emissions. To get the warming since a particular date, we subtracted the warming from that date (say 1990) from each term of the warming time series.

For the minimisation calculations, we varied a single parameter: the linear percentage decrease of methane by the year 2050, commencing in 2020. We employed Python's Nelder-Mead optimisation method to identify the methane percentage at which the emissions will reach a certain temperature goal.

Temporal boundary

This study primarily assesses New Zealand's contribution to warming since 1990 until the present, given the availability of emissions inventory data only since 1990. For the projections to 2050, we use a baseline year of 2020 as this is the most recent year in the inventory.

System boundary

The data used for this analysis includes all nationally reported agricultural emissions as outlined in New Zealand's National Inventory Report. This includes enteric methane, manure management, emissions from agricultural soils, field burning of agricultural residues, liming, and urea application.

Appendix 2: Mitigation potential of long and short-lived GHGs

Section 2 showed the extent to which different GHGs and sectors have contributed to additional global warming in recent years over and above the warming to the baseline year of 1990. In this Appendix, we will consider the potential of different GHGs and sectors for mitigation of global warming. As each GHG has a different lifetime in the atmosphere, the effects from past emissions persist for varying timeframes. This concept is referred to here as historical or 'maintained warming'. At any point, if GHG emissions are stopped entirely, the 'maintained warming' is the amount by which temperatures would fall as a result. As CO_2 and N_2O are long lived, stopping their emissions leads to only a small reduction, if any, in global temperatures, meaning the maintained warming from these long-lived gases is small. On the other hand, methane is short-lived, so stopping methane emissions would mean that the atmospheric methane levels would no longer be held up by ongoing methane emissions. Past emissions would be removed from the atmosphere though chemical reactions, and they would not be replaced with new emissions. Hence, the maintained warming for methane is much larger than for long lived gases.

In Figure 12 through Figure 15, the maintained warming is shown by the hatched areas as a negative value; in other words, the amount temperature would go down if the emissions of that sector or gas were halted since the baseline year. The change in temperature shown is relative to temperature in that baseline year, which is 1990 in the figures. Figure 12 shows the warming from each of New Zealand's economic sectors (agriculture, energy, industry and waste). The agricultural sector (blue in Figure 12) has the largest component of maintained warming, and hence provides the greatest potential for emissions cuts to cause cuts to global warming. Figure 13 through Figure 15 show the same data disaggregated by GHG. While the maintained warming is shown in Figure 12 as a negative value, another way to think of it is to equate to the amount of warming that is added to the system if you maintained emissions at 1990 levels compared to having no emissions from 1990 onwards. This is how maintained warming is shown in Figures 14 to 16. It is clear that methane (Figure 15) has the largest maintained warming.

These figures also show the 'additional warming' by the non-hatched areas. This is the amount of warming caused by emissions from each sector relative to the level of warming in 1990. From Figure 12, we see that while agriculture has the greatest potential impact on global warming from emissions cuts (blue hatched), the energy sector causes the greatest amount of additional warming (solid pink) between 1990 and 2020. It is clear from Figure 14 that CO_2 is the dominant gas from the energy sector, which has substantial level of additional warming, but negligible maintained warming.

The sum of maintained warming and additional warming has been termed the 'marginal warming' (Reisinger et al. 2021), as this quantity considers the difference between a future emission being released, or not being released (no-activity counterfactual). Figure 12 shows that New Zealand's emissions between 1990 and 2020 raised global temperatures by roughly an additional 0.7 thousandths of a degree. However, if New Zealand had emitted nothing at all in that period, temperatures would be nearly 0.8 thousandths of a degree cooler in 2020 relative to 1990. In other words, the difference in temperature in a scenario including or excluding New Zealand's emissions is 1.5 thousandths of a degree (i.e. New Zealand's marginal warming between 1990 and 2020).

The quantities of maintained versus additional warming depend entirely on the date used for the baseline. Figure 4 from Section 2 shows that for a baseline of the year 1850, at which point we would assume emissions are approximately zero, all warming is additional. Since pre-industrial times, more than half of New Zealand's contribution to warming comes from the agricultural sector.

Based on the definition of maintained warming, it might seem that warming due to carbon dioxide would only be additional. However, this is not the case for biogenic carbon. This notion of maintained and additional warming is conceptually aligned with the Carbon Opportunity Cost discussed previously. In the same way that constant methane "holds up" temperature, carbon from previous land clearing for agriculture persists in the atmosphere causing warming so long as that land remains in production. The opportunity cost of using land for agriculture is that the land is not used to store carbon as a natural ecosystem. In this way, warming from biogenic carbon emitted due to land clearing can also be thought of as maintained warming.

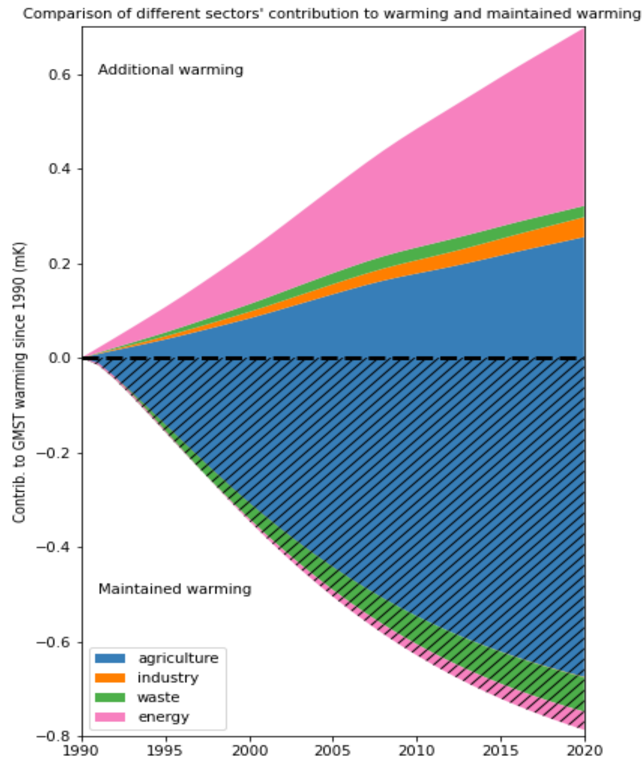

Figure 12: Additional warming from CH_4, CO_2 and N_2O emissions combined, relative to 1990 warming level (solid colours, shown with a positive sign convention), and maintained warming since 1990 (hatched areas, shown with a negative sign convention), shown by sector

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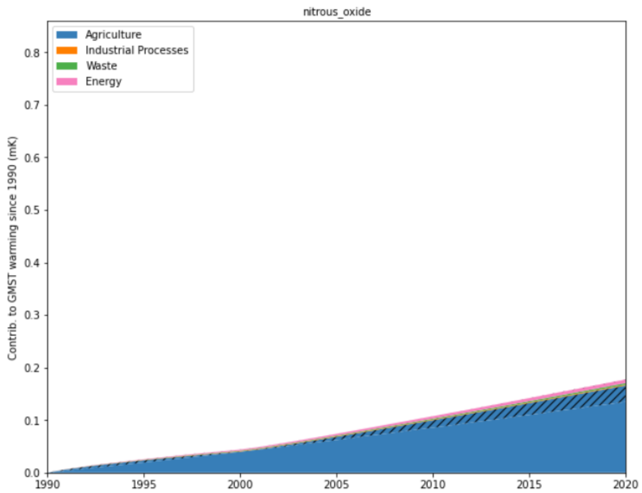

Figure 13:Additional (solid) and maintained (hatched) warming relative to 1990 from N_2O emissions. Here, both are shown with a positive sign convention, with the sum of the two representing the marginal warming.

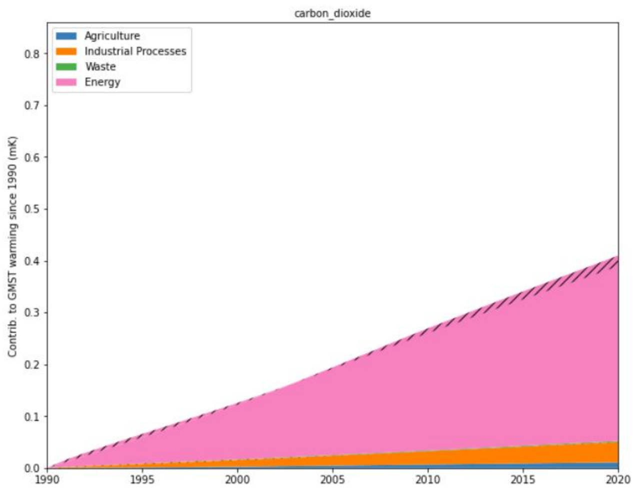

Figure 14: As Figure 9 for CO_2.

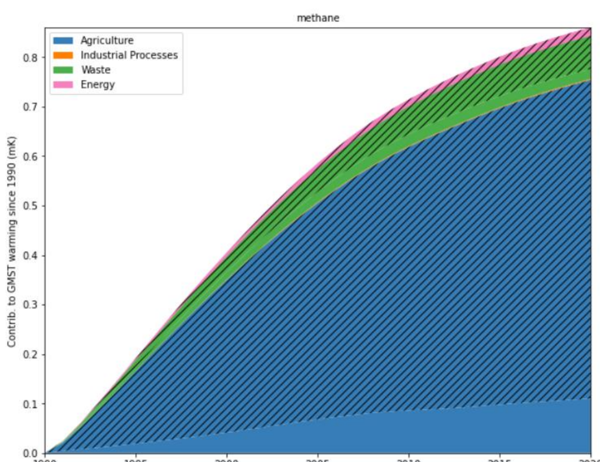

Figure 15: As Figure 9 for CH_4.

Figures 12 to 15 demonstrate that, while CO_2 from the energy sector is clearly responsible for a large proportion of the additional warming that has occurred since 1990, the large blue wedge of agriculture's maintained warming shows that the reduction of agricultural methane represents the greatest opportunity to reduce New Zealand's contribution to warming. Cutting emissions in the future will decrease the level of maintained warming (hatched) for any of the gases. However, because of CO_2 and N_2O's longer lifetimes, the maintained warming is relatively small. Its short lifetime means that CH_4's maintained warming is high, hence its high potential for reducing contributions to global warming.

Appendix 3: Glossary

Contribution to global warming from an emissions source (e.g. global emissions, emissions from a country, or a sector): This is calculated using a climate model by running the global model in a baseline simulation (Sim A) and running the model with the sector in question removed (Sim B). The magnitude of the difference between Sim A and B is the contribution to global warming from the source in question.

Additional warming: The warming from an emissions source (e.g. global emissions, emissions from a country, or a sector) relative to the same in a chosen base year.

Marginal warming: the warming from an emissions source relative to the absence of that emission. This is calculated using a climate model by running the global model in a baseline simulation (Sim A) and running the model with the sector in question removed for all times after the year you wish to start evaluating marginal warming from (Sim C). The magnitude of the difference between these is the marginal warming.

Net zero greenhouse gas emissions: Where emissions and removals of all GHGs sum to zero, with non-CO_2 GHGs scaled to CO_2-equivalent values using a climate emissions metric. GWP100 is commonly used for this.

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Appendix 2A: Solid foundations: Dairy's economic contribution to New Zealand, August 2023

Solid foundations

Dairy's economic contribution to New Zealand

04 September 2023

SENSE PARTNERS
DATA LOGIC ACTION

Key points

New Zealand's largest goods producing sector

- Dairy accounted for $11.3 billion[1] (3.2%) of GDP in the year to March 2023.
- Of this, dairy farming contributes $8 billion (2.2% of GDP) and dairy processing contributes $3.4bn (0.9%).
- Māori businesses own around $4.9b billion in assets in the dairy sector.

Dairy employs almost 55,000 people…

- The dairy sector sustained 54,787 jobs as at March 2023, with 38,462 on farm and 16,325 in dairy processing.
- The number of dairy processing jobs has grown at an average rate of 3.2% per year since 2019. The wider manufacturing sector, by contrast, has lost jobs at an average rate of 0.2% per year.
- The primary sector as a whole has seen employment contract by an average of 2.2% per year since 2019. Dairy farming jobs have been more resilient, falling by a more moderate 0.8% per year.
- Māori made up 16.5% of dairy farming employees and self-employed, up from 12.7% in 2015. The number of Māori employees has risen from 3,693 in 2015 to 4,040 in 2021.

… and is a cornerstone employer in many regions

- In Waimate, one in three jobs are in the dairy sector.
- Dairy also has a high employment share in South Taranaki (1 in 4 jobs), Westland (1 in 4.5 jobs), Southland (1 in 5 jobs), and Matamata-Piako (1 in 6.5 jobs).

The dairy sector pumps $3.6bn directly into workers' pockets…

- Median wages for dairy processing and dairy farming are higher than those in other comparable manufacturing and land-based industries. Total dairy processing wages were $2.2bn in the year to March 2023.
- Median wages in dairy processing reached $90,000 in 2023, having grown at an average rate of 3.4% per year between 2019 and 2023.
- Dairy farming wages have reached parity with the national median wage of $59,000 and have grown at an average 8.6% per year since 2019. Total dairy farming wages were $1.4bn in the year to March 2023.

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[1] Figures are rounded to 1 decimal place. Totals may not add due to rounding.

…providing a big boost to regional economic spending

- Dairy's high median wages amplify high employment shares in many regional economies. In Waimate, wages paid by the dairy sector made up 52% of total wages paid in the district.
- The share was similarly high in South Taranaki (41%), Westland (44%), Southland (28%, and Matamata-Piako (24%).

The gender pay gap is decreasing in dairy processing;

- The gender wage gap has been steadily falling in dairy processing, from -35% in 2000 to -21% in 2021.
- As the female share of processing employment continues to grow (from 29% to 35% over this period) and more women are given the opportunity to develop greater skills and experience, the gap can be expected to close further.
- Limited long term progress has been made in closing the gender pay gap on-farm, although the gap is trending in the right direction over the past six years. Greater retention of female employees to support their skills development will be crucial for maintaining this trend.

Dairy generates $25.7bn of exports: 1 in 4 of every export dollar New Zealand earns

- The value of dairy exports has risen 45% (or $7.9bn) in the five years to April 2023, and now tops $25.7bn.
- Businesses operated by Māori authorities exported $207 million in milk powder, butter, and cheese in 2021 (latest data available).
- Dairy generates more than one in every four dollars of New Zealand's foreign exchange receipts from goods and services exports.
- It is New Zealand's largest goods exporter by a significant margin, accounting for 35% of goods exports.

Individual dairy products are larger than many other export sectors

- With a combined $4.6 billion in exports, butter, AMF and dairy spreads alone are larger than horticulture ($3.8bn) and wine exports ($2.8bn).
- Protein products exports ($3.4bn) alone exceed New Zealand's exports of electrical machinery ($2.3bn), seafood ($1.9bn), and aluminium ($1.6bn).
- Three dairy product groups have each increased their export revenue by more than $1bn since 2019 – whole milk powder, skim milk powder, and protein products.

New Zealand exports dairy products to over 140 markets, and is less concentrated in major markets than commonly perceived

- 54.1% of dairy sector exports are sold to its top five markets. This is the lowest concentration of New Zealand's top 10 export sectors by some margin.
- Wood (89.4% of exports to its five biggest markets) has the highest concentration, followed by wine (85.2%), aluminium (78.3%), meat (72.4%), seafood (71.2%), and electrical machinery (63.9%).

Dairy farming is a shock absorber for regional economies, maintaining local spending even when milk prices drop

- Dairy farmers spent $7.9bn on goods and services in the local economy in the year to March 2023, on top of $8bn in returns to land, labour, and capital.
- The level of spend has been stable and consistent over time, even as milk prices have fluctuated. Price volatility is absorbed in dairy farmers' profits, while farms kept purchasing inputs from the wider economy.
- Dairy farming is a top 10 purchaser in 1/3rd of all industries, representing 31.5% of GDP.
- Farmers' purchases support economic activity and jobs in sectors including:
    - Fertiliser and pesticide manufacturing ($256m GDP and 801 jobs supported)
    - Banking and financing, financial asset investing ($383m GDP and 1,323 jobs)
    - Pharmaceutical, cleaning, and other chemical manufacturing ($134m GDP and 1,203 jobs)

Dairy processors bought $19.6bn of goods and services from farms and firms in the year to March 2023

- This is on top of generating $3.8bn in returns to land, capital, and labour.
- Processors' spending included $5bn in inputs other than raw milk, supporting economic activity and jobs in a range of industries such as:
    - Road transport and freight services ($450m GDP and 4,785 jobs supported by dairy processing.)
    - Polymer and rubber product manufacturing ($168m GDP and 1,231 jobs supported by dairy processing.)
    - Advertising, market research, and management services ($129m GDP and 1,292 jobs supported by dairy processing.)
- Dairy processing is a top 10 purchaser in ¼ all of industries, representing 19% of GDP.

Smaller national herd, bigger efficiency gains

- The number of dairy cows peaked in 2015 at just over 5 million. Since then, it has fallen 3.5%.
- Production per cow has continued to increase, rising an average 2.4% per annum between 2015 and 2022.
- This has helped to drive increases in export value per cow. Nominal value per cow has risen 56.9% since 2018. Adjusted for inflation, real values per cow have risen 19.7%.

Despite its success, dairy faces a range of barriers to export growth...

- Much of the global dairy market remains highly constrained by tariffs:
    - 57% of global dairy consumption takes place behind tariff barriers greater than 20%.
    - 87% of dairy consumption is behind a barrier of 10% or more.
- While New Zealand's bilateral and regional trade agreements have been highly beneficial, a range of tariffs still apply to dairy exports under them. We estimate tariffs paid on our dairy exports to our top 20 markets are around $1.5bn.
- In addition, we estimate non-tariff measures impose costs of around $7.8bn on New Zealand dairy exports.
- Additional government efforts to reduce tariffs and non-tariff measures would generate higher prices and returns to New Zealand farmers and processors.

...as well as risks to its supply chain resilience

- The dairy sector also faces material risks to its economic resilience from potential disruptions in its transport supply chains.
- It has limited port options due to the size of vessels it needs to achieve scale economies (85% of exports go via Tauranga, Lyttleton and Otago).
- Rail and road freight links to ports are also both vulnerable to disruption.
    - The road network converges on multiple chokepoints, many of which dairy relies on to get fresh milk to processing plants. Delays at these chokepoints can cost industries hundreds of thousands of dollars per day.
    - Rail access to the Port of Tauranga, the largest dairy export port in New Zealand, is reliant on a single rail line, the East Coast Main Trunk.
- Continued improvements in the efficiency of ports, aligned with greater investments in more reliable and resilient road and rail networks would provide the dairy sector with a stronger foundation for maintaining its international competitiveness and growing its contribution to New Zealand's economy.

Contents

Figures

Tables

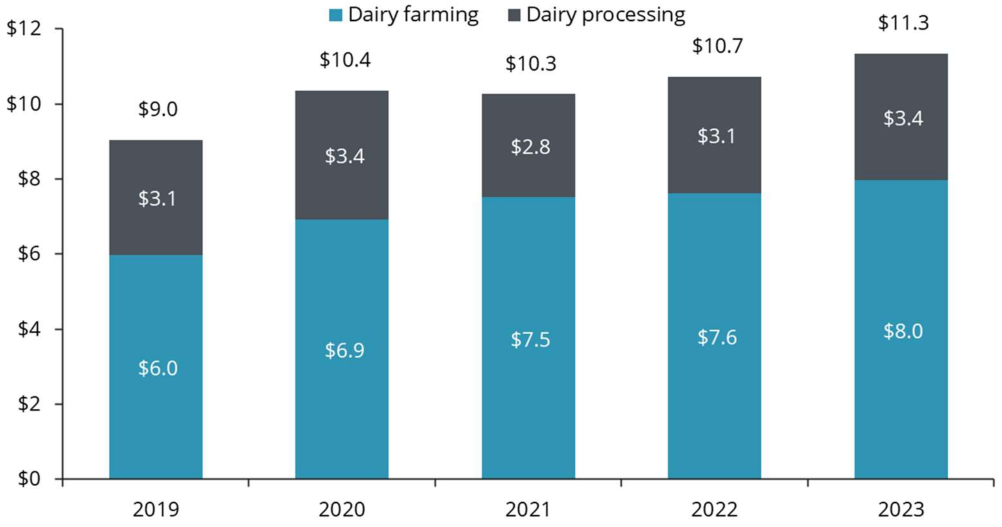
1. Economic contribution

1.1. Dairy's contribution to GDP

Dairy directly added $11.3 bn to the NZ economy in 2023.

The dairy sector contributed just over $11.3 billion to New Zealand's GDP in the year to March 2023. This represented 3.2% of total GDP. Of this, dairy farming contributes $8.0 billion (2.2% of GDP) and dairy processing contributes $3.4 billion (0.9%).

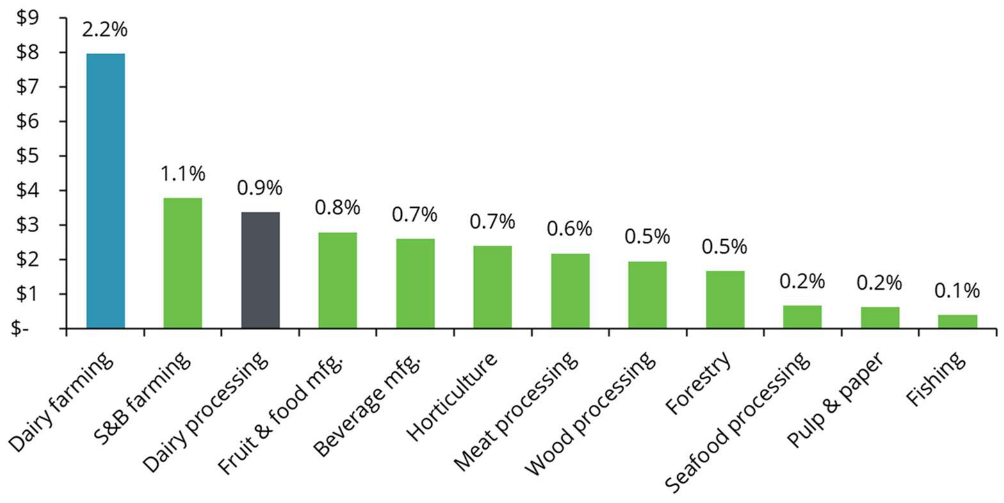
FIGURE 1: DAIRY SECTOR CONTRIBUTION TO GDP, $B, NOMINAL, YEAR TO MARCH



Source: Statistics New Zealand, Sense Partners

This makes Dairy the largest goods producing industry in NZ.

FIGURE 2: INDUSTRY VALUE ADDED, $B, YEAR TO MARCH 2023



Source: Statistics New Zealand, Sense Partners

The contribution made by dairy farming, at $8 billion, is the largest of all goods producing sectors, in both the primary sector and manufacturing. Sheep and beef farming, at $3.8 billion in GDP (1.1% of the total) was a relatively distant second. Dairy processing alone is the third largest goods producing sector in the country, at $3.4 billion.

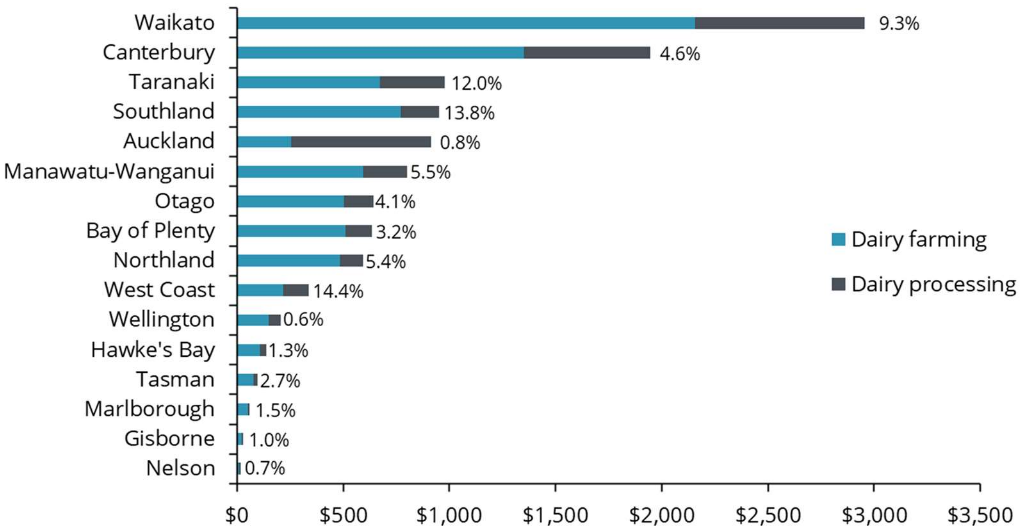
Dairy is a major contributor to many regional economies.

The dairy sector, as a land based activity, is naturally spread out over the country. By contrast, sectors like manufacturing and services tend to be concentrated in larger cities. This means that the dairy sector makes an important contribution to spreading economic activity across regional New Zealand.

Dairy plays a prominent role in regions like Southland, where it represents 13.8% of regional GDP. The West Coast (14.4%) and Taranaki (12.0%) have similarly high shares of economic activity coming from the dairy sector.

Even in regions with high GDP from other activities, Dairy continues to play a prominent role. Of Waikato's GDP of $31.8bn, 9.3% came directly from Dairy, while Canterbury drew 4.6% of its $42.4bn GDP from the sector.

FIGURE 3: REGIONAL GDP CONTRIBUTION, $M, YEAR TO MARCH 2023



Source: Statistics New Zealand, Sense Partners

Dairy is the largest sector in three regions, the West Coast, Taranaki, and Southland. In the Waikato, with the largest dairy sector by GDP, only the professional services sector is larger. Of 54 sectors, Dairy is among the 10 largest in nine regions.

Only in major cities (Auckland and Wellington) and areas dominated by Horticulture (Gisborne, Hawke's Bay, Tasman, and Nelson) is Dairy a smaller sector.

GDP from dairy exceeded $2.9 billion in the Waikato and neared $2 billion in Canterbury. In Southland and Taranaki, the contribution was over $1 billion, and more than half a billion in Manawatu and Otago.

1.2. Dairy's contribution to employment

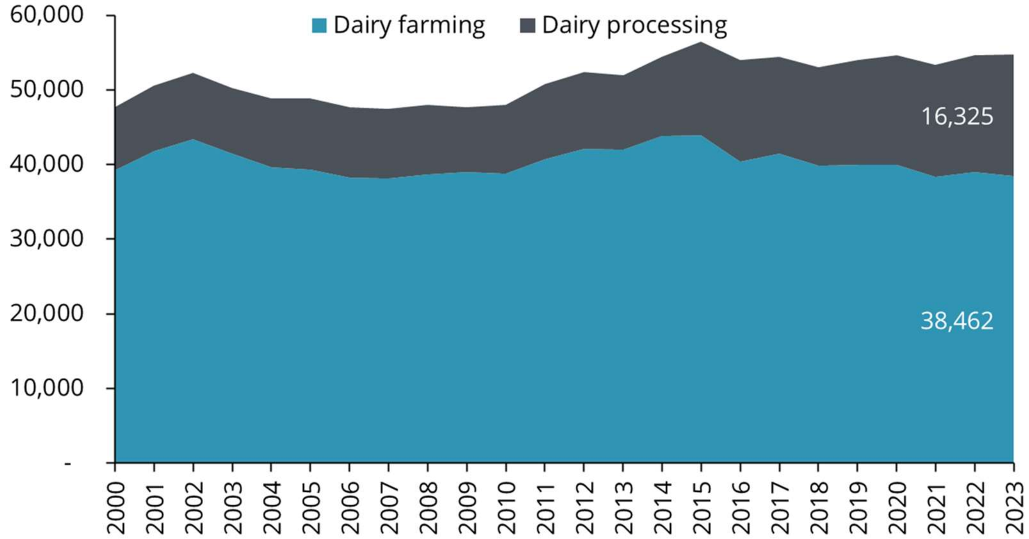
The dairy sector has sustained a stable number of jobs since 2015

The dairy sector generated 54,787 jobs in the year to March 2023.[2]

Employment in dairy processing has increased, rising 16.9% from 13,960 jobs in 2019 to 16,325 in 2023. This, combined with a slight5 decrease in farming employment, has seen processing's share of total dairy employment rise from 25.9% in 2018 to 29.8%.

Despite labour shortages, dairy production has remained steady, implying improved on-farm productivity.

FIGURE 4: DAIRY SECTOR EMPLOYMENT, YEAR TO MARCH



Source: Statistics New Zealand, Sense Partners

Dairy has achieved gains in jobs that the wider primary sector hasn't

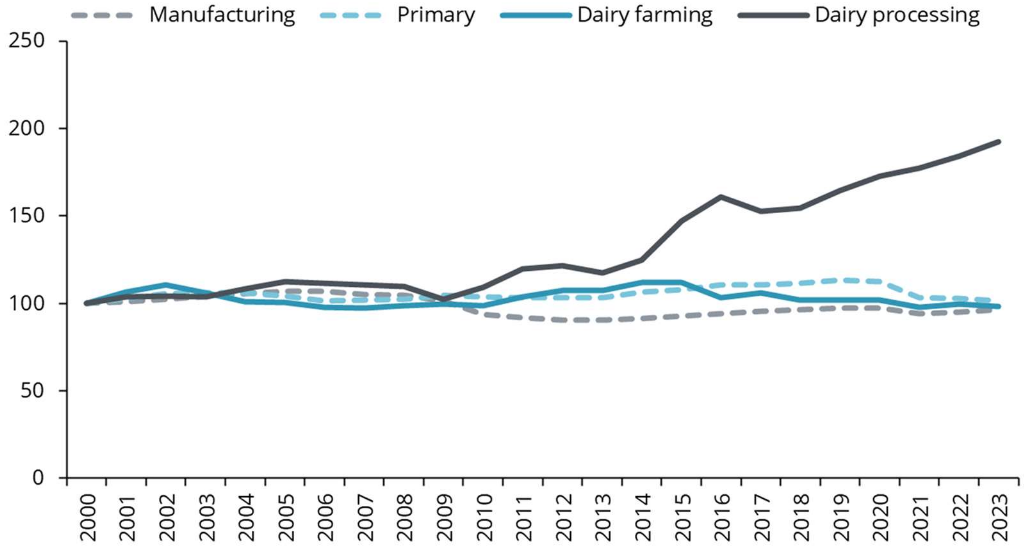
Over the long term, the dairy sector has proven to be a source of growth in employment.

Jobs in dairy processing have grown by 92% since 2000 (Figure 5). This compares very favourably with the wider primary and manufacturing sectors. The primary sector has only grown 1.5% since 2000, while manufacturing jobs are down by 3.6%.

The number of dairy farming jobs has been largely steady. Job numbers are currently down 3.8% since 2000, but the total has ebbed and flowed.

[2] This is the number of unique jobs recorded by Statistics New Zealand. Some individuals may work multiple jobs, meaning the number of people employed is lower.

FIGURE 5: EMPLOYMENT INDEX BY INDUSTRY, 2000 = 100, YEAR TO MARCH



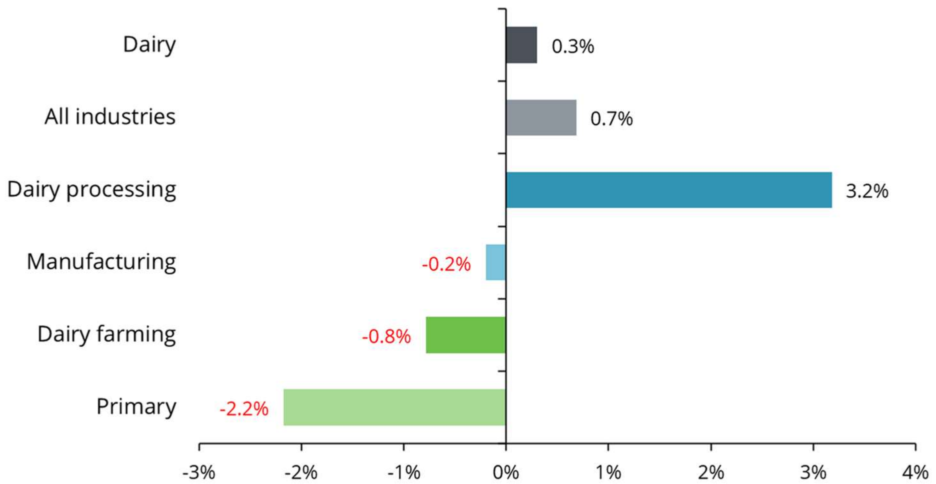
Source: Statistics New Zealand, Sense Partners

When looking at recent growth rates, the Dairy sector as a whole is lagging total jobs growth. However, this is due to the large role played by the services sector in economic activity.

Dairy processing is outperforming the wider manufacturing sector, growing an average 3.2% per year since 2019. This compares well to the average reduction of 0.2% per year experienced in the manufacturing sector.

While dairy farming employment has been falling in recent years (-0.8% per year on average), the annual rate is half that of the wider primary sector (-2.2%).

FIGURE 6: AVERAGE ANNUAL JOBS GROWTH, YEAR TO APRIL 2019-2023



Source: Statistics New Zealand, Sense Partners

Labour shortages and wage rises are placing pressure on farmers

The reductions in dairy farming employment have primarily been in waged and salaried employees, with jobs down 10.1% since 2019 (Figure 7). In part this reflects the challenges of finding workers, rather than a reduction in the level of employment the sector can sustain.

FIGURE 7: DAIRY FARMING: WORKERS PAID WAGES/SALARIES VS SELF-EMPLOYMENT

Source: Statistics New Zealand, Sense Partners

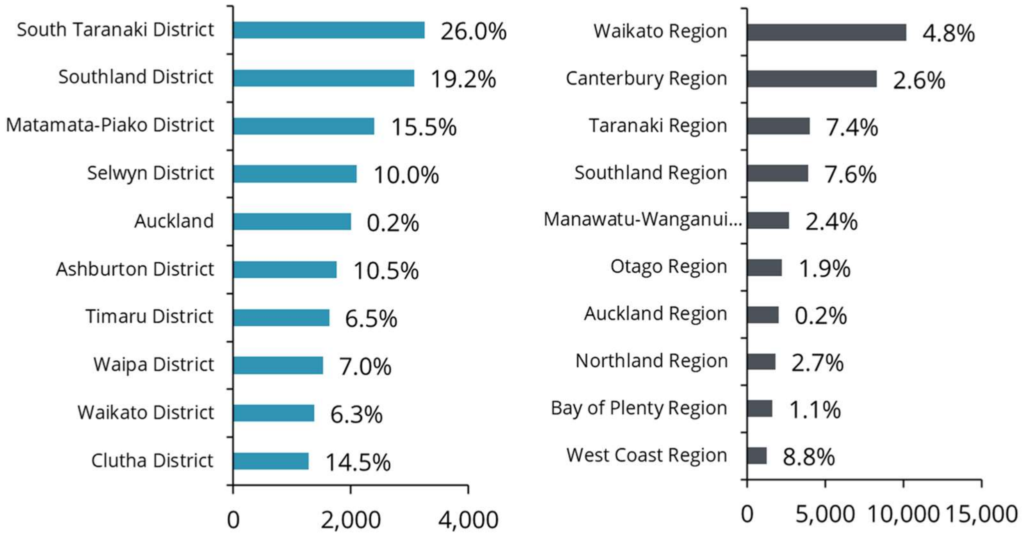
Federated Farmers have run an employment survey in the dairy farming sector. Challenges in attracting and retaining employees is a key theme in the results. High labour costs mean that employers face tough choices between employing sufficient staff, at high cost, and paying themselves well. Over half of respondents were paying themselves less than staff, with 11% not paying themselves at all.

Dairy is a cornerstone employer in many regions

The dairy sector is a major employer in many parts of the country. Figure 8 below shows the top 10 districts and regions for dairy sector jobs. The label along each column shows the dairy sector's share of total jobs in that area.

At a district level, South Taranaki has the highest number of dairy employees, at 3,250. These dairy farming and processing jobs represent 26% of all jobs in the region. With over 10,000 dairy workers, the Waikato is home to approximately 18% of dairy's total workforce.

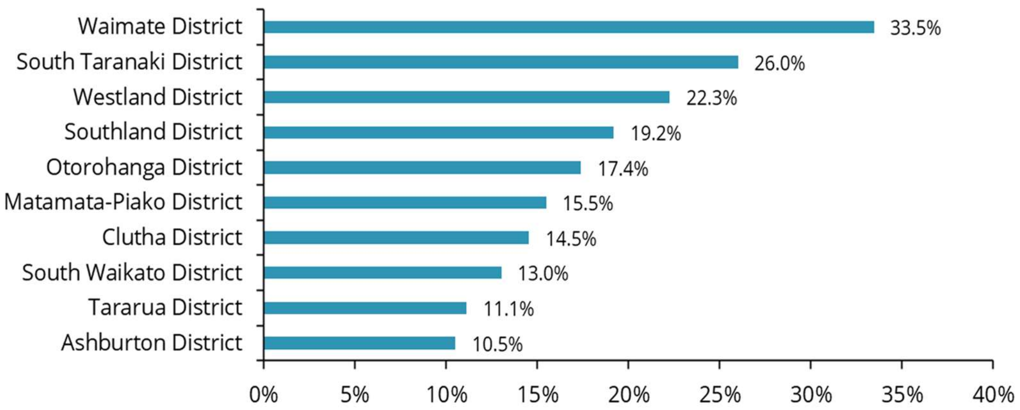
FIGURE 8: COUNT OF DAIRY EMPLOYEES, TOP 10 DISTRICTS AND REGIONS



Source: Statistics New Zealand, Sense Partners

Figure 9 shows the top 10 districts by share of dairy employment. 1 in 3 people in Waimate district are employed in the dairy sector. Dairy employs more than 20% of workers in both South Taranaki and Westland districts. There are a further eight districts where dairy accounts for more than 1 in every 10 jobs.

FIGURE 9: DAIRY SHARE OF TOTAL EMPLOYEES, TOP 10 DISTRICTS



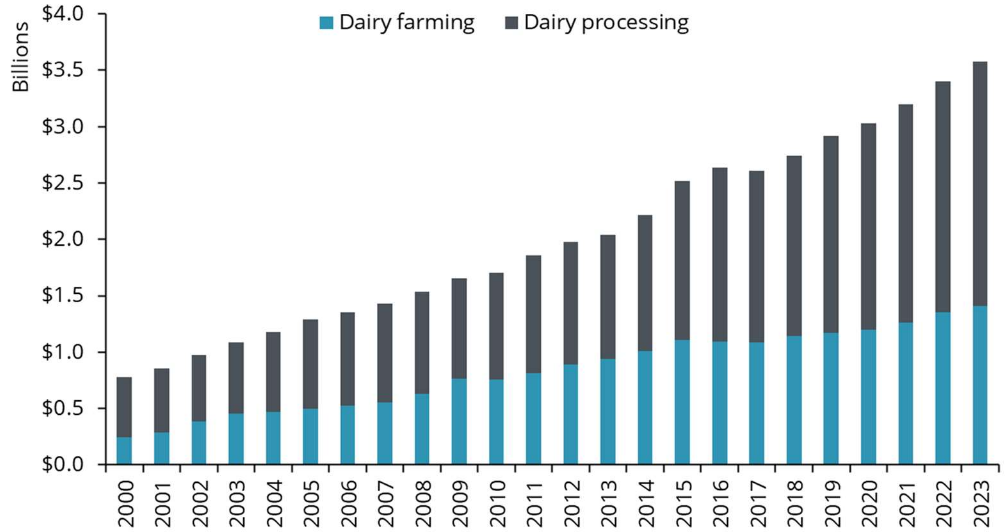
Source: Statistics New Zealand, Sense Partners

1.3. Dairy's contribution to wages and income

Dairy paid $3.6bn in wages across New Zealand in 2023

The dairy sector paid $3.6 billion in wages across New Zealand in the year to March 2023. Of this, $1.4 billion came from dairy farming, up 20% since 2019. The remainder, $2.2 billion, came from processing, up 24% since 2019.

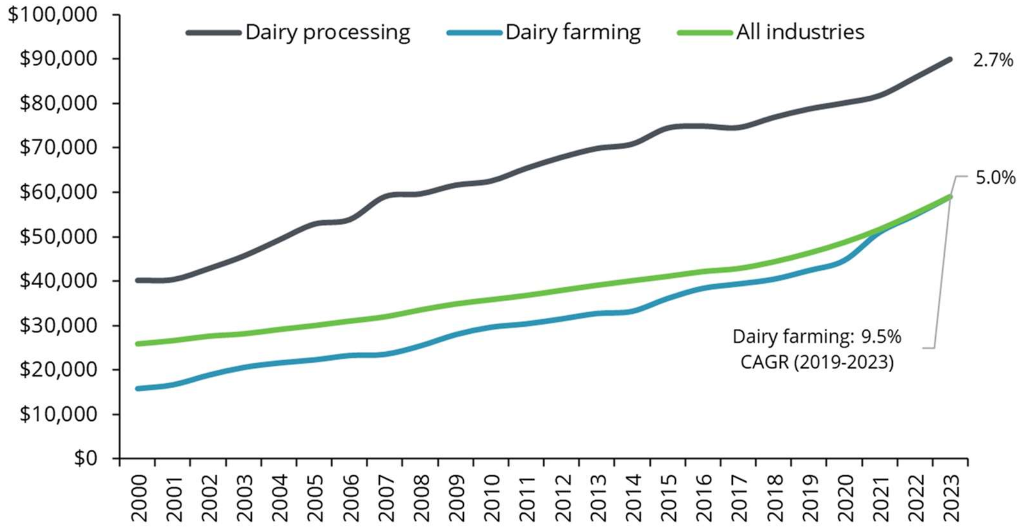
FIGURE 10: DAIRY SECTOR TOTAL WAGES PAID, YEAR TO MARCH



Source: Statistics New Zealand, Sense Partners

Dairy farming wages have caught up to the national average

FIGURE 11: DAIRY SECTOR MEDIAN WAGES, YEAR TO MARCH

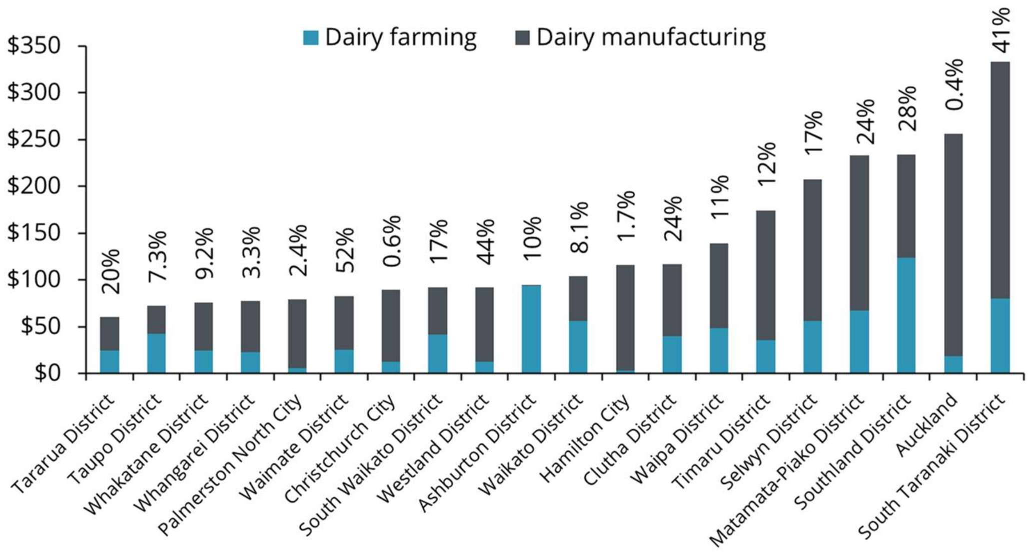


Source: Statistics New Zealand, Sense Partners

The dairy farming median wage has grown an average 9.5% between 2019 and 2023, outpacing average wage growth of 5% in the wider economy. The median dairy farming wage now sits at $59,000 – the same as the median wage for all sectors.

Higher wages amplify the value of dairy employment for local economies

FIGURE 12: DAIRY SECTOR TOTAL WAGES PAID, TOP 20 TA, 2022[3]



Source: Statistics New Zealand, Sense Partners

Looking across New Zealand, the higher wages in the dairy sector amplify the value of dairy employment to communities:

- While dairy makes up 33.5% of employment in Waimate, its share of wages sits at 52%.
- For South Taranaki, a high concentration of dairy processing jobs at Whareroa, combined with the high median wage in dairy processing, means the 26% employment share is translated into a 41% share of wages paid in the district.
- The same is true for the Southland district where dairy provides 5.4% of jobs and accounts for 28% of wages.

Dairy pays more than comparable sectors…

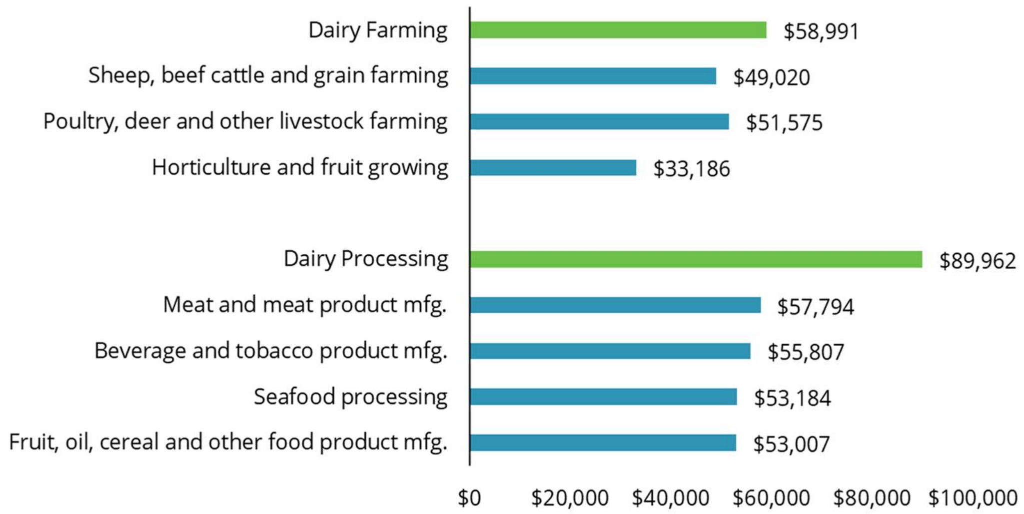
Figure 13 below shows median wages across sectors similar to dairy. These are sectors that are likely to locate in similar areas to dairy, and where there is a reasonable chance of transferrable skills. We can see that wages in both farming and processing are considerably higher than comparable sectors:

[3] Detailed employment data for Territorial Authorities is only available for 2022.

- The median wage for dairy farming, at almost $59,000, was 14.4% higher than poultry and deer farming.
- Dairy processing jobs enjoy a substantial wage premium. At almost $90,000, they are 55.7% higher than the meat processing sector.

These high wages give the dairy sector a comparative advantage in attracting employees compared to these similar sectors. For regional economies, a higher concentration of dairy relative to these other sectors will provide a larger economic boost.

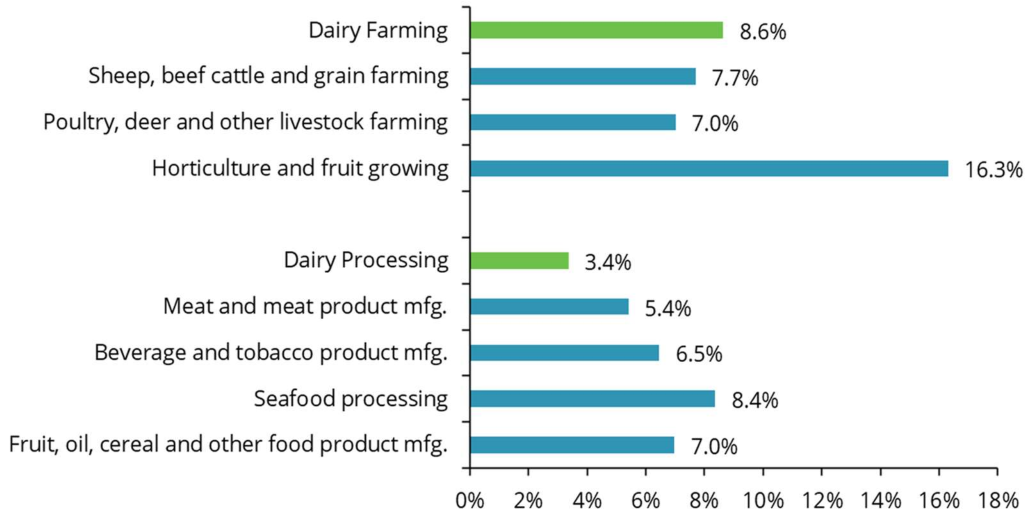
FIGURE 13: MEDIAN WAGES ACROSS COMPARABLE SECTORS, YEAR TO MARCH 2023



Source: Statistics New Zealand, Sense Partners

…which is prompting other sectors to up their game

FIGURE 14: AVERAGE ANNUAL GROWTH IN MEDIAN WAGES, 2019 – 2023



Source: Statistics New Zealand, Sense Partners

Dairy farming boosted wages at a faster rate than most, at 8.6% per annum on average. Higher wage growth in the horticulture sector is occurring in the context of considerably lower median wages.

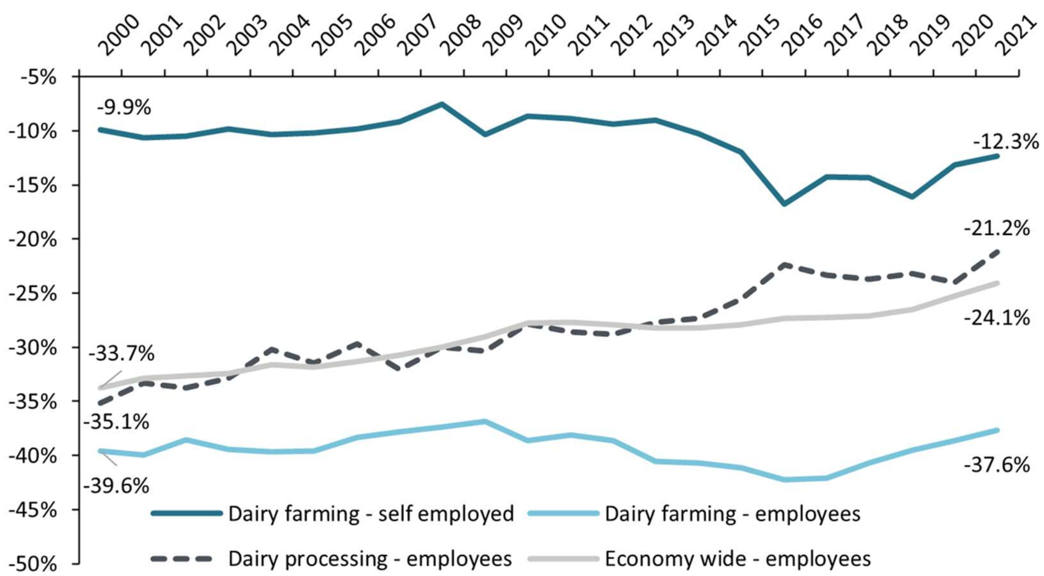
Wage growth in dairy processing has averaged 3.4% per annum since 2019. The existing high wages in dairy processing mean the modest 3.4% rise equates to an annual average gain of $2,790. This is compared to $3,089 in beverage and tobacco processing, $2,746 in meat processing, $3,653 in seafood processing, and $3,129 in fruit, oil, cereal and other product processing. Despite higher gains in some sectors, there remains a considerable wage premium in dairy processing.

The gender wage gap is falling steadily in dairy processing

The pay gap in dairy processing employment has fallen from -35% in 2000 to -21% in 2021. At the same time, the female share of employment in processing has risen from 29% to 35%. This is a positive trend that has seen the sector achieve a lower wage gap than the economy-wide average.

The wage gap is likely partly due to disparities in seniority and experience. To sustain this progress, the sector will need to ensure that new female employees are retained within the sector and given the opportunity to develop skills and experience. As the female workforce achieves this, we would expect the wage gap to continue falling.

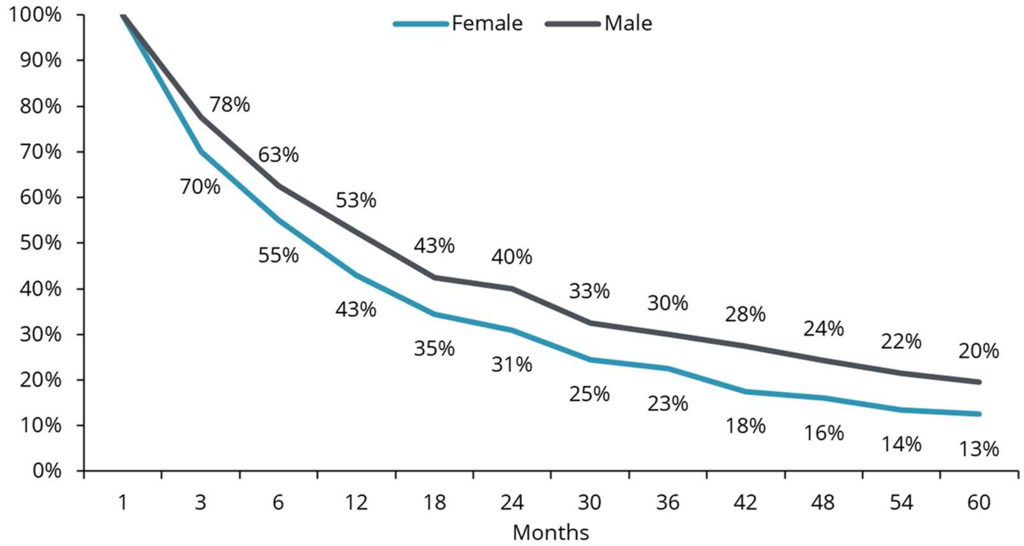
FIGURE 15: AVERAGE WAGE GAP (FEMALES RELATIVE TO MALES)



Source: Statistics New Zealand, Sense Partners

For dairy farming, the wage gap in employees over the last two decades has moved around an average of 39%. The female share of employment has risen from 26% to 30%, reflecting some progress in bringing females into the sector. However, the retention rate for females remains below that of males (Figure 16). Retaining females in the sector is key to enabling females to build up experience and seniority in the sector, helping to lower the wage gap.

FIGURE 16: DAIRY FARMING RETENTION RATES



Source: Muka Tangata

1.4. Dairy and the Māori economy

Data on the Māori economy is relatively sparse. In recent years, a more concerted effort has been made by government agencies and industry groups to collect a wider range of data, however the frequency and pace of collection remains an issue.

Māori dairy assets amount to $4.9bn

In 2018, Māori businesses owned $4.9b billion in assets in the dairy sector.[4] This estimate was split across self-employed ($537m), employers ($1,579m), and collectives ($2,749m). A separate analysis by Chapman Tripp in 2017 estimated 10% of dairy production assets were owned by Māori.[5]

In 2021, 11% of dairy farming businesses (859 businesses) were Māori owned. This share has been stable since 2018, the earliest year for which data is available.[6]

Māori employment on-farm is rising

In terms of employment, 7% of dairy farms (589) were significant employers of Māori,[7] a share that has also been stable since 2018.

In 2021, Muka Tangata report that Māori made up 16.5% of dairy farming employees and self-employed, up from 12.7% in 2015. Applying this proportion to our estimate of total employment, the number of Māori employees has risen from 3,693 in 2015 to 4,040 in 2021.

Māori businesses exported $207m in dairy products in 2021

According to Statistics New Zealand, businesses operated by Māori authorities[8] exported $207 million in milk powder, butter, and cheese in 2021. This was an increase of 35.3% on 2020.[9]

Grassland farms operated by Māori owned businesses made up 3% of total grassland farmland, however the average size of each farm, at 569 ha, was 3.8 times larger than the New Zealand wide farm average of 148 ha.

Māori owned farms made up 1.4% of the dairy herd - 87,900 cattle, of which 72,100 were milking cows and heifers.

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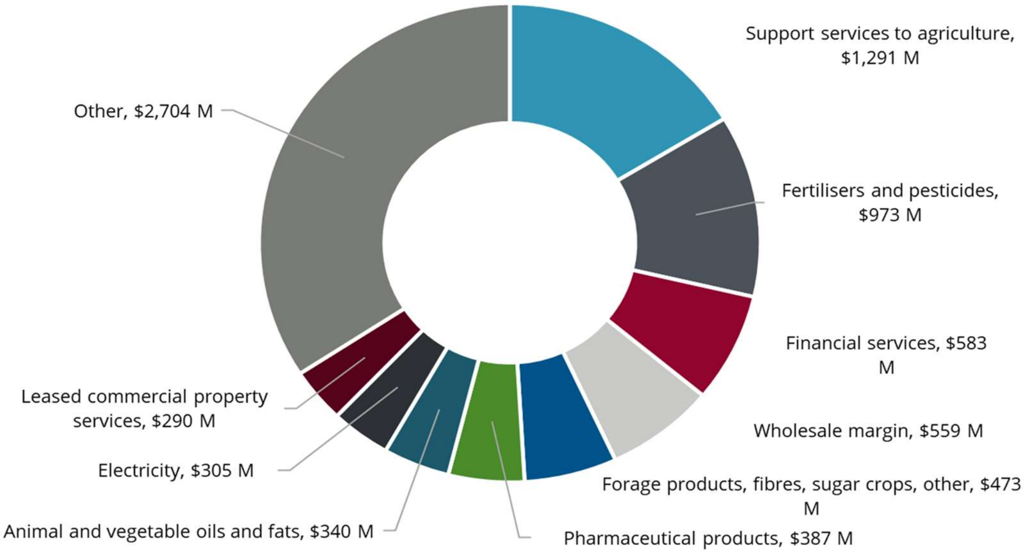
[4] BERL (2021) *Te Ōhanga Māori 2018: The Māori Economy 2018*.
[5] Chapman Tripp (2017) *Te Ao Māori: Trends and insights*
[6] Muka Tangata (2023) *WDC Dashboard*. https://www.sweetanalytics.co.nz/portals/wdc-dashboard-muka-tangata/
[7] Defined as a business in which 75% of employees are of Māori ethnicity or descent.
[8] Statistics New Zealand defines Māori authorities as "businesses involved in the collective management of assets held by Māori."
[9] Statistics New Zealand (2022) *Tatauranga umanga Māori – Statistics on Māori businesses: 2021.*

1.5. Dairy's support of other industries

Dairy boosts economic activity in a diverse range of sectors

Dairy farmers spent just over $15.7 billion on inputs in the year to March 2023. This is made up of $7.9 billion purchasing goods and services in the wider economy, with an additional $8 billion in returns to land, labour, and capital. This included $1.3 billion in agricultural support services, $983m on fertilisers and pesticides, and $583m in financial services.

FIGURE 17: INPUT EXPENDITURE, DAIRY FARMING, YEAR TO MARCH 2023



Source: Statistics New Zealand, Sense Partners

Dairy farming is a top 10 purchaser in 35 industries representing 31.5% of GDP

Agriculture, forestry, and fishing support services has a total GDP of $2.9 billion in the year to March 2023. Of the sector's total output, 22.2% is purchased by dairy farmers. This equates to $632m in GDP supported by dairy farming and 7,729 jobs in the sector directly supported by dairy farming, out of a total of 34,891 jobs.

Some other examples include:

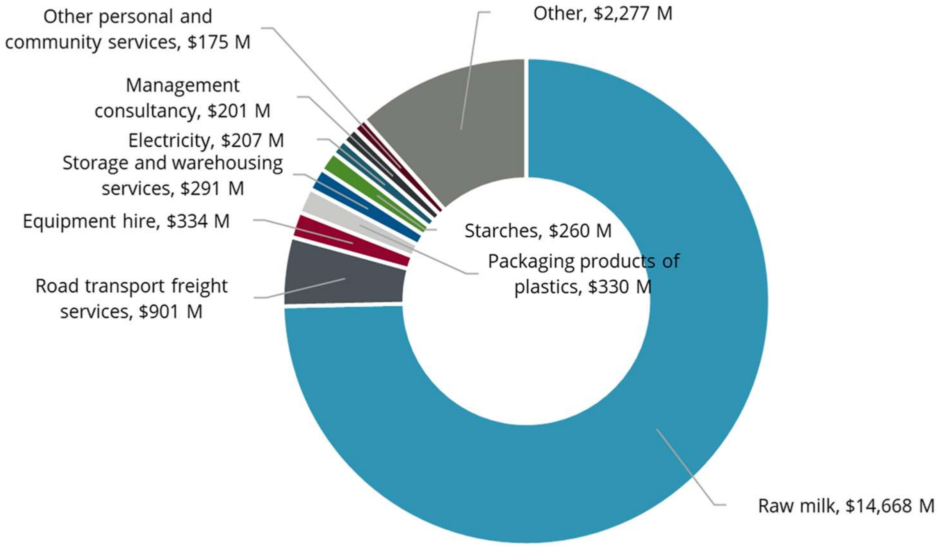
- Fertiliser and pesticide manufacturing (52% dairy share, $256m GDP and 801 jobs supported by dairy farming.)
- Banking and financing, financial asset investing (3.3% dairy share, $383m GDP and 1,323 jobs supported by dairy farming.)
- Sheep, beef cattle, and grain farming (4.4% dairy share, $213m GDP and 1,110 jobs supported by dairy farming.)
- Pharmaceutical, cleaning, and other chemical manufacturing (18.6% dairy share, $134m GDP and 1,203 jobs supported by dairy farming.)

- Legal and accounting services (2.6% dairy share, $176m GDP and 1,172 jobs supported by dairy farming.)

Dairy processors spent $5.0bn beyond the farm gate

Dairy processors, as would be expected, are major consumers of raw milk, spending over $14.7 billion on dairy farming's key output in the year to March 2023. However, the sector spent an additional $5.0bn on goods and services from the wider economy. This is on top of $3.8bn in returns to capital, land, and labour.

FIGURE 18: INPUT EXPENDITURE, DAIRY MANUFACTURING, YEAR TO MARCH 2023



Source: Statistics New Zealand, Sense Partners

Dairy processing is a top 10 purchaser in 25 industries representing 18.8% of GDP

Some examples from among the dairy processing sectors top sources of inputs include:

- Road transport and freight services (9.7% dairy share, $450m GDP and 4,785 jobs supported by dairy processing.)
- Equipment rental and hiring services (6.5% dairy share, $243m GDP and 907 jobs supported by dairy processing.)
- Polymer and rubber product manufacturing (9.0% dairy share, $168m GDP and 1,231 jobs supported by dairy processing.)
- Warehousing and storage services (22.7% dairy share, $174m GDP and 1,831 jobs supported by dairy processing.)
- Advertising, market research, and management services (1.9% dairy share, $129m GDP and 1,292 jobs supported by dairy processing.)

2. Export update

2.1. Dairy's role in our export economy

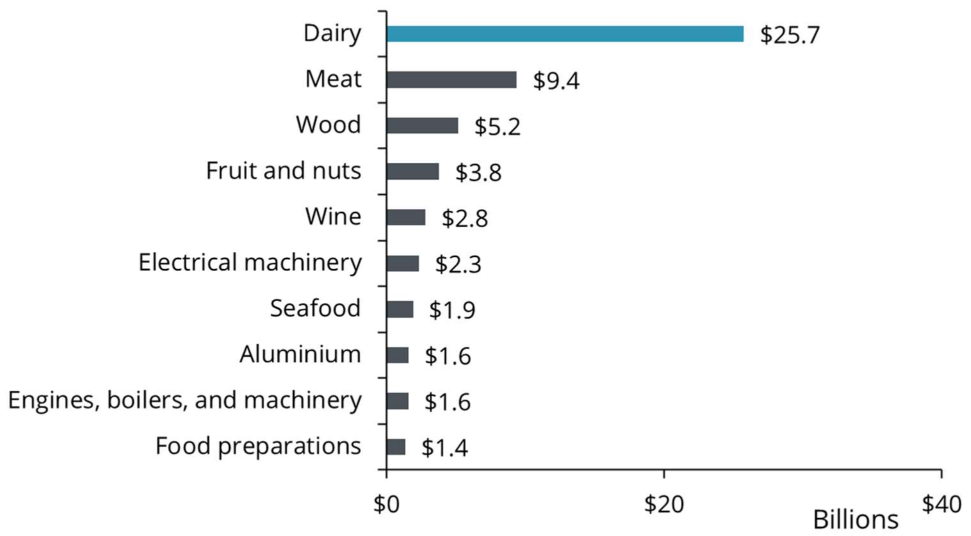
Dairy remains our largest export earner

Dairy exports in the 12 months to April 2023 amounted to $25.7 billion. This represented 35.3% of goods exports for the period, and 27.3% of total goods and services trade.

Dairy is New Zealand's largest goods exporting sector in New Zealand by quite some margin. Dairy export earnings were approximately 2.8 times those from meat, approximately 9.2 times wine, and greater than meat, wood, fruit, wine, and seafood combined.

Dairy exports are over 3.4 times that of our largest services export, tourism. This of course reflects the impact of the COVID-19 pandemic. However, even prior to Covid exports of travel services, including personal, business, and education related travel, peaked at $15.9 billion in export revenue in the year to March 2020.[10] In that same year, dairy exports reached $19.9 billion in revenue, 1.25 times greater.

FIGURE 19: TOP 10 GOODS EXPORTS, YEAR TO APRIL 2023



Source: Statistics New Zealand, Sense Partners

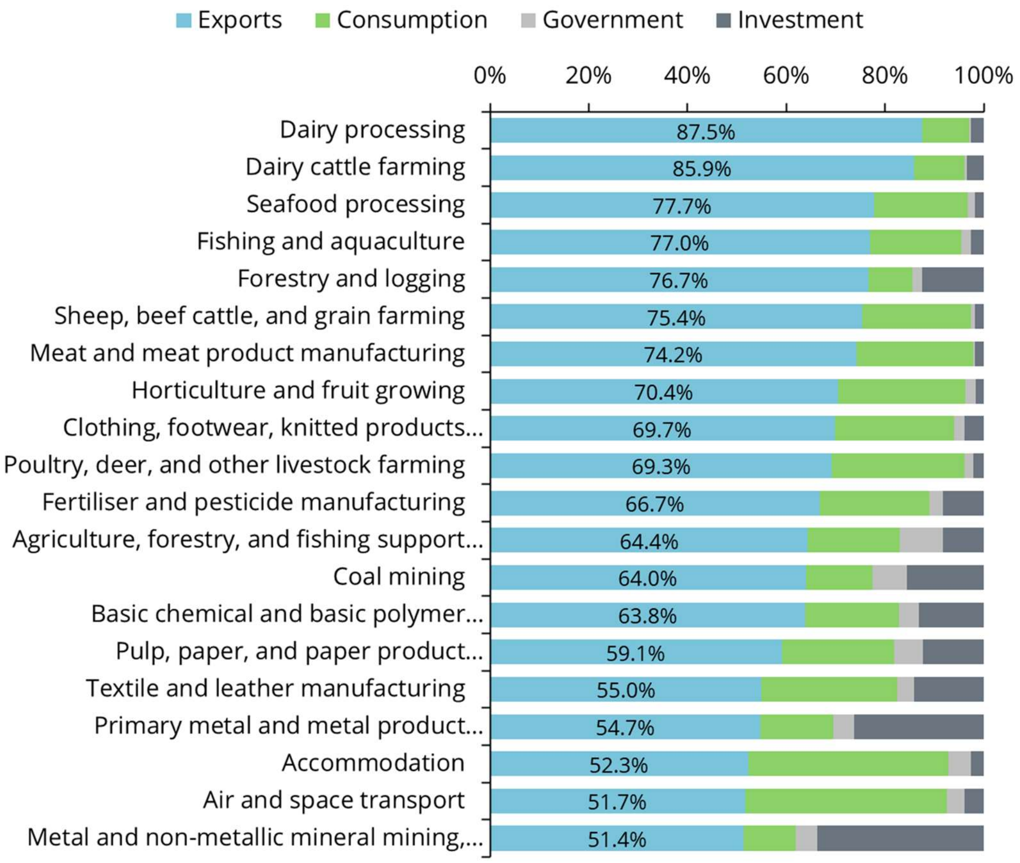
[10] Statistics New Zealand (2023) *New Zealand International Trade*.
https://statisticsnz.shinyapps.io/trade_dashboard/
This includes a period at the start of the year in which travel was being impacted by the COVID-19 pandemic.

Dairy remains the most globally connected sector in NZ

87.5% of dairy processing output by value is exported, making it the most globally connected industry in New Zealand. Dairy farming is not far behind, with 85.9% of output value ultimately exported.

The remainder is consumed in the domestic market, either by households (10.3%) or through government catering (less than 0.3%). A small portion (3.5%) registers as investment in the form of accumulating inventories. This is indicative of the strength of dairy as our largest export sector, and the scale of production relative to domestic demand.

FIGURE 20: ULTIMATE DISPOSITION BY INDUSTRY, YEAR TO MARCH 2020



Source: Statistics New Zealand, Sense Partners

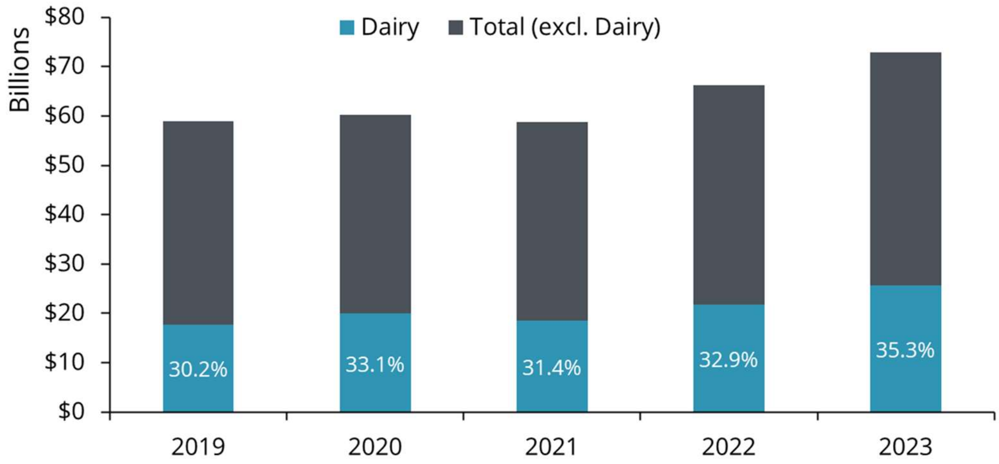
Dairy's share of goods exports trended upward during COVID-19

Total New Zealand goods exports have grown 24% in the five years to April 2023, an average of 5.4% per annum. This represents an increase of $13.9 billion. The dairy sector has driven much of this growth.

Excluding dairy, goods exports have grown 15% over the same timeframe, a gain of $6.0 billion. Dairy exports have grown 45%, an average 9.6% each year, more than double the rate of other exports (3.5%). The dairy sector has added $7.9 billion to exports in that time.

This export success is translating into an increasing share of New Zealand's total goods exports. Dairy exports now represent 35.3% of goods exports, up from 30.2% in the year to April 2019.

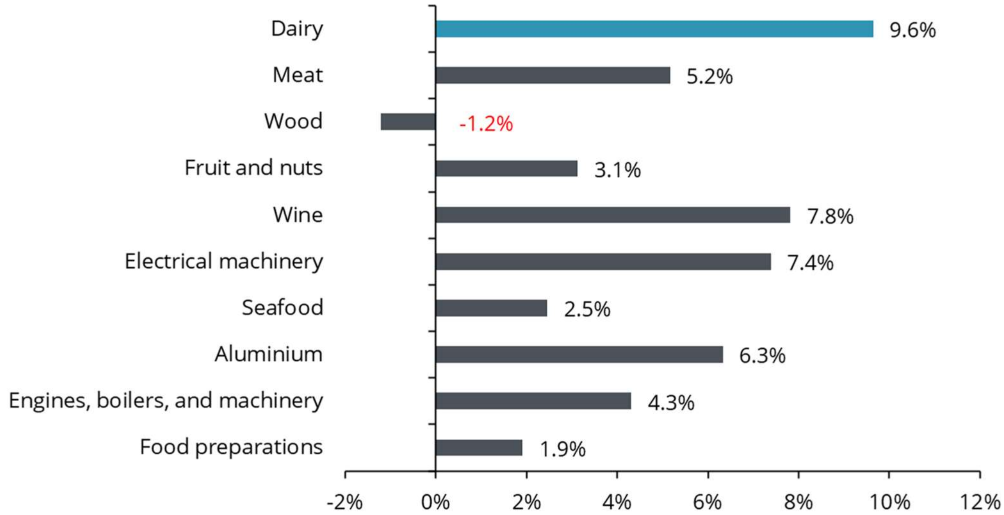
FIGURE 21: DAIRY SHARE OF GOODS EXPORTS, YEAR TO APRIL



Source: Statistics New Zealand, Sense Partners

Dairy has been the fastest growing goods exporting sector...

FIGURE 22: AVERAGE ANNUAL GROWTH IN EXPORTS, YEAR TO APRIL 2019 – 2023



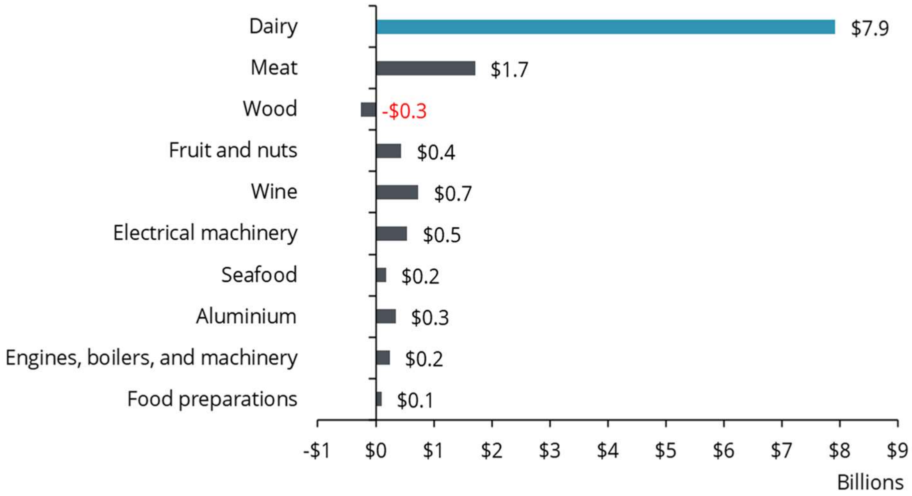
Source: Statistics New Zealand, Sense Partners

...and has added $7.9B in export revenue since 2019

Dairy's high growth rate translates to an increase in export revenue of $7.9 billion since 2019. This is an order of magnitude greater than any other sector. Dairy has *added* more export revenue over the past five years than any other sector, except meat, earned in the year to April 2023.

The export revenue growth from dairy also exceeds the combined growth of the next nine biggest goods export sectors combined.

FIGURE 23: CHANGE IN GOODS EXPORTS, YEAR TO APRIL 2019 – 2023



Source: Statistics New Zealand, Sense Partners

Dairy's growth has exceeded expectations. In 2020, the Ministry for Primary Industries published the 'Fit for A Better World Roadmap'. The report set a goal for dairy export revenues to reach $23.1 billion by 2030.[11] The sector's 2023 export result of $25.7 billion bettered the 2030 target by $2.6 billion.

[11] Ministry for Primary Industries (2020) *Fit for a Better World: Background analysis n export earnings in the primary sector*. https://www.mpi.govt.nz/dmsdocument/41319-Fit-for-a-better-world-Background-analysis-on-export-earnings-in-the-primary-sector

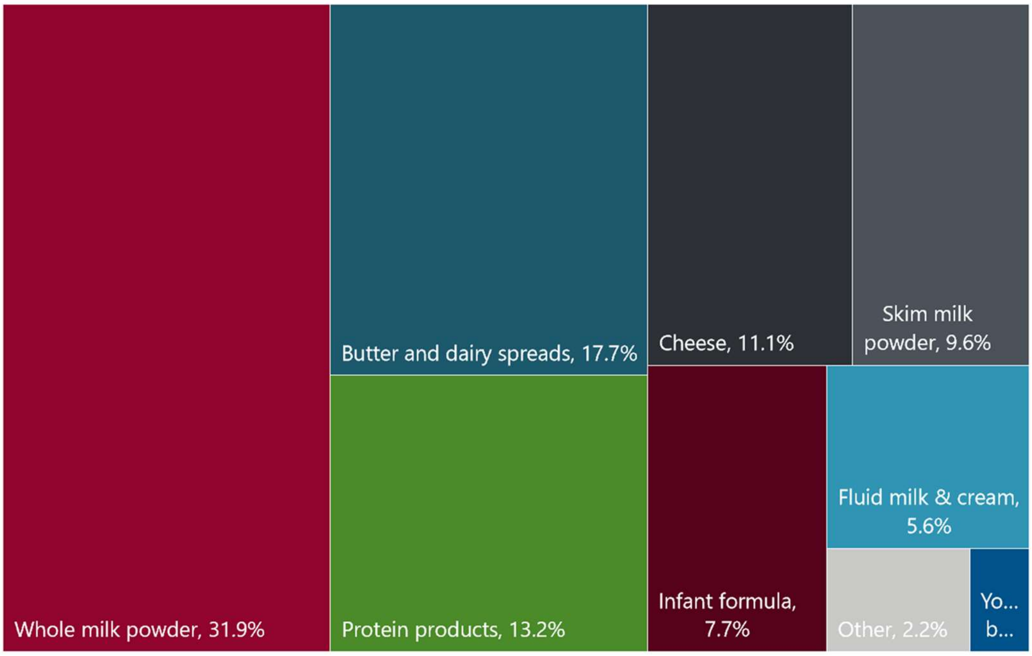
1.5. What the dairy sector sells

The dairy export product mix continues to evolve

Whole milk powder, at 31.6% of dairy exports by value, remains our largest dairy product export. While this share is down from the product's 36.9% share in 2019, exports have grown 25.2% in that same time. This reflects a level of diversification in dairy product exports that has seen the whole milk powder share fall from as high as 40% in 2015.

The falling share reflects the strong growth in several other product groups. The top gainer was protein products,[12] up 120% ($1.9 billion) since 2019 to achieve $3.4 billion in exports in 2023. Its share has consequently risen from 8.6% to 13.2%.

FIGURE 24: EXPORTS BY PRODUCT GROUP, YEAR TO APRIL 2023



Source: Statistics New Zealand, Sense Partners

Individual dairy products would be major export sectors in their own right

Some dairy products would be major export industries in their own right if considered individually:

- With $4.6 billion in exports, butter and dairy spreads are larger than horticulture ($3.8 billion), and wine exports ($2.8 billion).
- Protein products ($3.4 billion) exceed electrical machinery ($2.3 billion), seafood ($1.9 billion), and aluminium ($1.6 billion).

---

[12] Protein products include whey (0404), casein (3501), and caseinates (3502).

Three dairy products - whole milk powder, skim milk powder, and protein products - have each **added** more than $1 billion in export revenue since 2019. Exports of fluid milk and cream ($1.4 billion) have grown sharply from $814m in 2019.

TABLE 1: EXPORTS BY PRODUCT GROUP, YEAR TO MARCH 2023

Product group	Share (2023)	Export revenue (2023)	Growth (2019-2023)
Whole milk powder	31.9%	$8.2B	25.2%
Butter and dairy spreads	17.7%	$4.6B	21.3%
Protein products	13.2%	$3.4B	120.3%
Cheese	11.1%	$2.9B	47.7%
Skim milk powder	9.6%	$2.5B	116.4%
Infant formula	7.7%	$2.0B	31.4%
Fluid milk & cream	5.6%	$1.4B	76.1%
Other	2.2%	$0.6B	49.1%
Yoghurt, buttermilk, and kephir	0.9%	$0.2B	55.3%

Source: Statistics New Zealand, Sense Partners

1.6. Where the dairy sector sells

China is driving growth in dairy exports, but gains are widespread

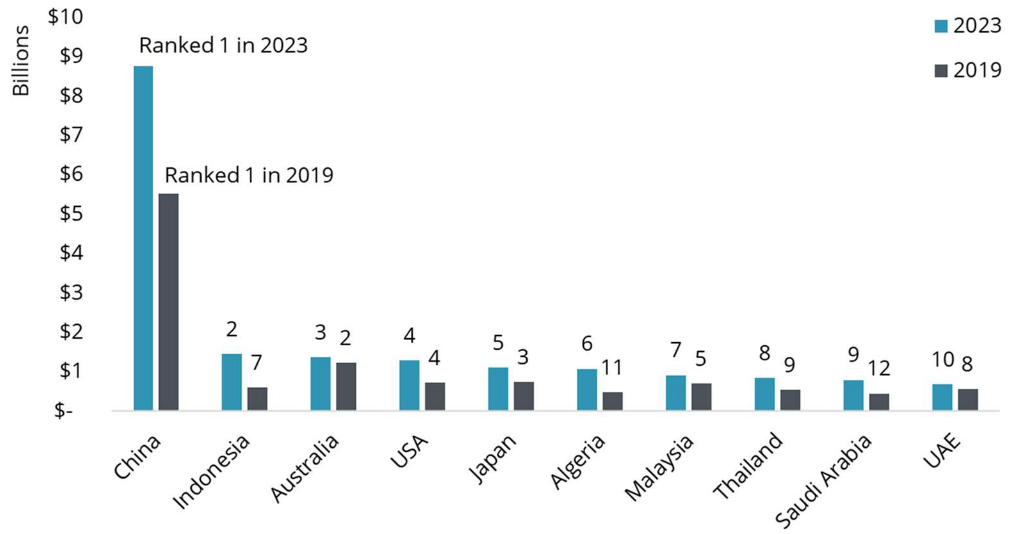
Over the 2019-2023 period our fastest growing major dairy export markets (greater than $100m in 2023) were Sudan (+191% to $121.2m), Guatemala (+178% to $112.5m), Indonesia (+145% to $1.4bn), and Algeria (+127% to $1.1bn).

The largest dollar gain was in China, with an increase of $3.3bn (+37%) between the year to April 2019 and 2023. An additional 11 markets recorded gains greater than $200m, and 4 markets gained more than $100m. Indonesia (up $848.9m), Algeria (up $594.9m), and the USA (up $555.5m) each netted gains in excess of half a billion dollars, while exports to the EU increased $218.6m (64%).

All of our 10 largest markets in 2023 have recorded gains greater than $100m since 2019. More than half of our total markets achieved growth in revenue. 85 of 140 (61%) markets recorded gains totalling $8.8bn, while the remaining 55 markets recorded loses totalling just $900m.

Exports to Russia fell 89% to $14.9m, as exporters responded to the Russian invasion of Ukraine. Sizeable falls were also seen in Chile (-52% to $51.2m), Sri Lanka (-45% to $216.7m), Hong Kong (-19% to $402m), Peru (-16% to $11.5m), and Egypt (-16% to $233.2m).

FIGURE 25: TOP 10 DAIRY EXPORT MARKETS, YEAR TO APRIL 2023

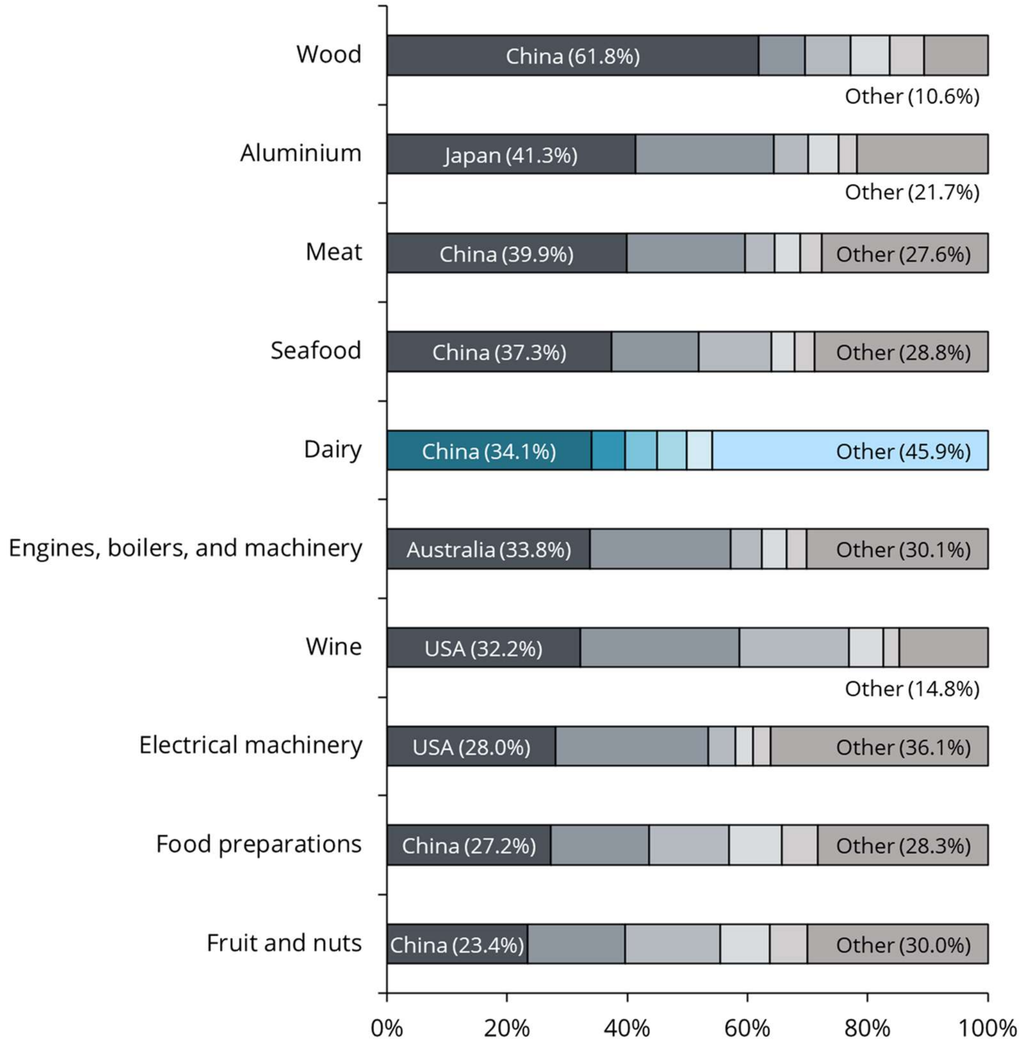


Source: Statistics New Zealand, Sense Partners

Dairy has a more diverse and less concentrated customer base

54.1% of dairy sector exports are sold to the top five markets. This is the lowest concentration of all New Zealand top 10 export sectors by some margin. Wood (89.4%) has the highest concentration, followed by wine (85.2%), aluminium (78.3%), meat (72.4%), seafood (71.2%), and electrical machinery (63.9%).

FIGURE 26: SHARE OF EXPORTS BY EXPORT DESTINATION, YEAR TO APRIL 2023



Source: Statistics New Zealand, Sense Partners

New Zealand dairy products are exported to 140 different markets. Engines, boilers, and machinery sold to 169 markets, and electrical machinery sold to 191 markets. All other top 10 goods export sectors sold to fewer markets than dairy, some by a considerable margin. Meat products were exported to 98 markets, wood to 77 markets, fruit and nuts to 80 markets, and wine to 116 markets.

TABLE 2: SHARE OF EXPORTS BY EXPORT DESTINATION, YEAR TO APRIL 2023

Product	1st	2nd	3rd	4th	5th	Other
Wood	China (61.8%)	Japan (7.8%)	USA (7.6%)	Korea (6.6%)	Australia (5.7%)	Other (10.6%)
Aluminium	Japan (41.3%)	Korea (23.1%)	Netherlands (5.6%)	Australia (5.1%)	USA (3.0%)	Other (21.7%)
Meat	China (39.9%)	USA (19.7%)	Japan (4.8%)	Netherlands (4.3%)	UK (3.7%)	Other (27.6%)
Seafood	China (37.3%)	USA (14.6%)	Australia (12.1%)	Japan (3.8%)	Spain (3.4%)	Other (28.8%)
Dairy	China (34.1%)	Indonesia (5.6%)	Australia (5.3%)	USA (4.9%)	Japan (4.2%)	Other (45.9%)
Engines, boilers, and machinery	Australia (33.8%)	USA (23.4%)	UK (5.1%)	Canada (4.2%)	Chile (3.4%)	Other (30.1%)
Wine	USA (32.2%)	Australia (26.5%)	UK (18.2%)	Canada (5.8%)	Germany (2.6%)	Other (14.8%)
Electrical machinery	USA (28.0%)	Australia (25.5%)	Fiji (4.5%)	Korea (3.0%)	UK (2.9%)	Other (36.1%)
Food preparations	China (27.2%)	USA (16.4%)	Indonesia (13.3%)	Australia (8.8%)	Japan (6.0%)	Other (28.3%)
Fruit and nuts	China (23.4%)	EU - other (16.3%)	Japan (15.8%)	Taiwan (8.2%)	USA (6.4%)	Other (30.0%)

Source: Statistics New Zealand, Sense Partners

1.7. The barriers Dairy faces

High tariffs stand between us and the world's largest consumers

Table 3 below shows the 20 largest consumers of dairy products in the world. India, consuming the equivalent of 258.4 bn litres of milk each year accounts for 26.8% of global consumption. They apply an average 31.7% tariff against imports of New Zealand dairy products.

The next largest consumer is the EU, at 16.4% of global consumption. These consumers are behind an even higher tariff barrier, with an average 46.7% applied to New Zealand dairy products.

In total, 56.8% of global consumption takes place behind tariff barriers greater than 20%. 86.8% of consumption is behind a barrier of 10% or more. Only 7.8% of consumption is behind a barrier of less than 1%.

Progress in accessing major dairy markets is best reflected in the tariffs applied by China. At just 0.3%, this is a low barrier to accessing the world's 5th largest dairy market. This is a key reason that China is our largest market, taking 34% of our exports by value. There are still major gains to be made from successfully lowering tariff barriers into other major markets.

TABLE 3: TOP 20 DAIRY CONSUMERS AND THE TARIFFS THEY APPLY TO NZ DAIRY

Country	Dairy consumption (Billion Litres equivalent)	Share	Average dairy tariff
India	258.4	26.4%	31.7%
EU27	158.3	16.2%	46.7%
USA	91.4	9.3%	19.6%
Pakistan	56.9	5.8%	18.4%
China	51.0	5.2%	1.6%
Brazil	32.6	3.3%	16.9%
Russia	30.7	3.1%	12.5%
Turkey	17.4	1.8%	106.6%
UK	16.8	1.7%	48.8%
Mexico	16.7	1.7%	18.2%
Bangladesh	10.7	1.1%	21.5%
Uzbekistan	10.4	1.1%	12.0%
Sudan	10.1	1.0%	32.9%
Canada	9.8	1.0%	110.8%
Egypt	9.7	1.0%	6.9%
Argentina	9.5	1.0%	16.9%
Iran	9.3	1.0%	28.3%

Country	Dairy consumption (Billion Litres equivalent)	Share	Average dairy tariff
Japan	8.8	0.9%	25.3%
Ukraine	8.2	0.8%	8.6%
Australia	8.0	0.8%	0.0%

Source: Global Trade Atlas, Statistics New Zealand, World Bank, Sense Partners

Tariffs impose a $1.5b cost on NZ dairy trade

TABLE 4: TOP 20 NZ DAIRY EXPORT MARKETS AND THE TARIFFS FACED

Destination	Value (NZD) & share (%)	Duties paid[13]	Average duties paid	Average tariff for all dairy
China	$8.76 B (34.1%)	$219 M	6.6%	1.6%
Indonesia	$1.43 B (5.6%)	$31.2 M	2.2%	0.8%
Australia	$1.36 B (5.3%)		0.0%	0.0%
USA	$1.27 B (4.9%)	$97.1 M	7.7%	19.6%
Japan	$1.09 B (4.2%)	$116 M	10.6%	25.3%
Algeria	$1.06 B (4.1%)	$57.9 M	5.4%	21.6%
Malaysia	$0.90 B (3.5%)	$6.55 M	0.7%	3.9%
Thailand	$0.84 B (3.3%)	$20.6 M	2.5%	15.0%
Saudi Arabia	$0.78 B (3.0%)	$38.9 M	5.0%	4.8%
UAE	$0.67 B (2.6%)	$33.4 M	5.0%	4.8%
Taiwan	$0.66 B (2.6%)	$0.33 M	0.1%	0.9%
Philippines	$0.64 B (2.5%)		0.0%	0.3%
Singapore	$0.61 B (2.4%)		0.0%	0.0%
EU 27	$0.58 B (2.3%)	$213 M	36.7%	46.7%
Korea	$0.57 B (2.2%)	$181 M	31.6%	46.8%
Viet Nam	$0.54 B (2.1%)	$1.11 M	0.2%	0.7%
Mexico	$0.48 B (1.9%)	$52.7 M	10.9%	18.2%
Hong Kong	$0.40 B (1.6%)		0.0%	0.0%
Bangladesh	$0.35 B (1.4%)	$53.8 M	15.3%	21.5%

[13] Note this table is based on MFN or FTA tariff rates (where applicable) and does not include product that may have been eligible for tariff reductions as part of import for re-export programmes, or temporary tariff reductions.

Destination	Value (NZD) & share (%)	Duties paid[13]	Average duties paid	Average tariff for all dairy
Egypt	$0.23 B (0.9%)	$9.35 M	4.0%	6.9%
Total	**$25.7 B (100%)**	**$1.52 B**	**5.9%**	

Source: Statistics New Zealand, World Bank, FAO[14], Sense Partners

Table 4 above shows the tariffs paid, in NZD, on New Zealand dairy products sent to our 20 largest markets. On $25.7bn in total dairy exports, our trade partners levied roughly $1.52bn in tariffs, equivalent to 5.1% of total value.

If tariffs applied on New Zealand products were lowered, demand for our products would likely rise. However, with no expected increases in milk production in New Zealand, and thus an inelastic supply, this higher demand would translate into higher prices. If these tariffs were lifted, much of this additional value would likely accrue to producers and processors here in New Zealand.

The final column of the table also shows the average tariff each country applies to all dairy products, including those we don't actually sell. This average is typically higher than the average duties faced by New Zealand products, reflecting the trade-chilling effects on New Zealand of high tariffs on some products. We tend to sell products that face lower tariffs.

This means that persistently high tariffs on some types of dairy product can prevent us from diversifying within markets. Our ability to offer a wider range of products is limited by the presence of higher tariffs outside our major export products.

Tariff barriers are likely even higher than these estimates

A key issue in trade analysis is estimating ad valorem equivalents (AVE). These represent tariffs as a percentage applied to the value of the goods being traded, as we have shown in Table 4 above. For example, Japan applies a 25% tariff to imports of some types of fluid milk.

However, tariffs are often made up of a monetary value per unit. For example, the USA applies a tariff of $1.56 per kg of some types of whole milk powder.[15] We can convert this to an AVE by looking at the tariff as a percent of the total value of each kg. The problem here is that this estimate is sensitive to changes in prices and exchange rates. The implied trade barrier may fluctuate over time, without any actual change in trade policy.

Where there is no trade in a good, this AVE cannot be estimated. No trade in a good may often signal there is an extremely high tariff barrier. Given this, excluding these products would underestimate the scale of tariff barriers. Accounting for tariff rate quotas (TRQs) is another challenge, with any single number unlikely to meaningfully capture the scale of this particular type of barrier.

[14] FAO data is supplemented with production statistics from national statistics agencies where available.
[15] 0402.21.90

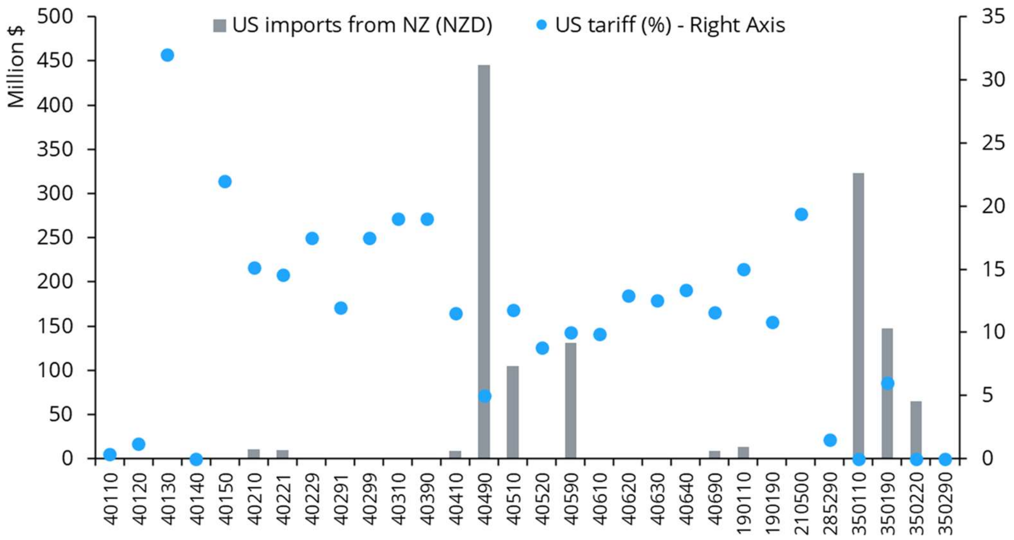
What this means is that the average tariffs we estimate in Table 4 above are likely an underestimate of the true scale of barriers. This is particularly so in the case of Japan. Japanese tariffs under the CPTPP agreement include a complex array of combined quotas with both ad valorum and monetary components. Japanese Most Favoured Nation (MFN) average tariffs for dairy products were as high as 81.6% in 2022.[16]

Out-of-quota tariffs in the US prohibit trade in our main dairy goods

The US is currently New Zealand's 4th largest dairy export market by value. Trade is dominated by high value proteins that are mostly subject to zero tariffs or tariffs less than 5%. Modest volumes of core dairy products enter via small WTO quotas with a lower in-quota tariff rate (IQTR). These core products, such as milkfat, powders, or cheese, typically dominate our trade with other markets. Yet the high out of quota tariff rate (OQTR) they face is prohibitive to trade outside some of specialised organic or retail applications.

For example, the US has a small WTO quota for butter (6,977MT, which represents 0.7% of domestic consumption of 985,000 MT) available to all countries with an IQTR of $123/MT. Any volume of trade outside of this incurs an OQTR of $1,541/MT. This demonstrates the importance of maintaining New Zealand's long held ambition of an FTA with the US. Reducing these barriers to trade will create a level playing field across the full range of New Zealand's dairy exports.

FIGURE 27: AVERAGE TARIFFS BY HS6 PRODUCT – USA, YEAR TO APRIL 2023



Source: Statistics New Zealand, World Bank, Sense Partners

[16] World Trade Organisation (2023) World Tariff Profiles 2023 - Japan

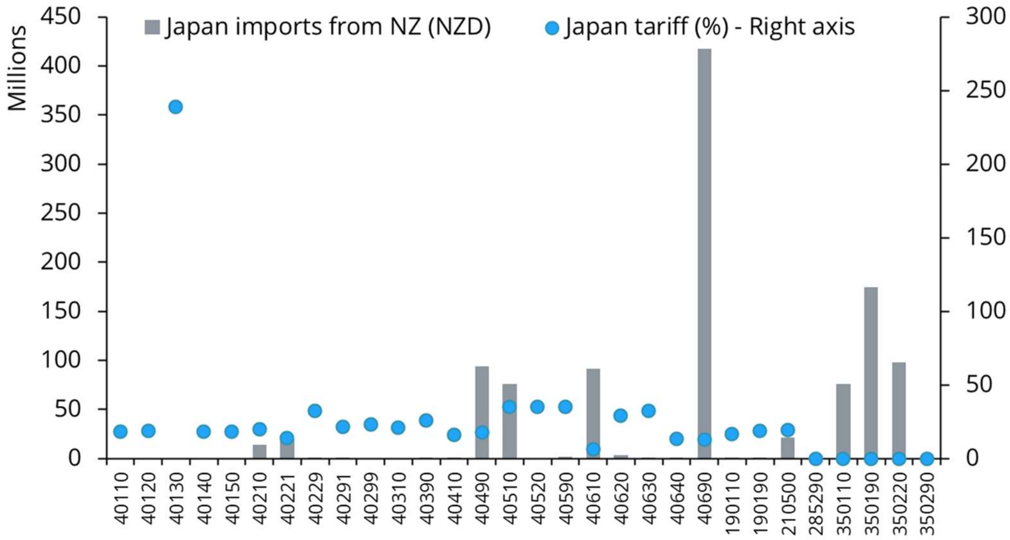
There is unfinished business in accessing the Japanese market

Japan is currently New Zealand's 5th largest dairy export market by value. As one of the largest diary importers in the world, Japan is an important strategic market for New Zealand. The Comprehensive and Progressive Trans-Pacific Partnership Agreement (CPTPP), which was concluded in 2017, provides some modest access into Japan. For example, a number of protein products became duty free on entry into force and most cheeses will be duty free by 2033.

However, CPTPP has not fundamentally changed the overall level of protection afforded to the Japanese dairy sector. Access to the Japanese market remains constrained by high tariffs and limited WTO quotas for other core dairy products. For example, even with CPTPP in place, butter access into Japan is highly constrained by a 3,719MT CPTPP quota, where the IQTR drops to 35% by 2029.

As a result, New Zealand's dairy trade with Japan tracks closely to the access provided under CPTPP, with trade dominated by cheese and proteins. This demonstrates the critical role of removing tariffs to support trade, the importance of addressing unfinished business in CPTPP, and looking for opportunities to enhance access into this high value market.

FIGURE 28: AVERAGE TARIFFS BY HS6 PRODUCT – JAPAN, YEAR TO APRIL 2023



Source: Statistics New Zealand, World Bank, Sense Partners

Existing trade agreements continue to deliver tariff reductions

Further tariff reductions are in the pipeline. This includes reductions from new agreements, such as the NZ-UK FTA.[17] This agreement eliminates tariffs on most dairy products in gradual increments. Milk powders, for example, will have their tariff reduced in four equal increments

[17] Ministry of Foreign Affairs and Trade (2022) *NZ-UK FTA: Chapter 2, Annex 2A, Subsection 2B-2-2*.

over 4 years, until they become duty free. Butters and Cheese are given a tariff rate quota that is gradually lifted over 6 years until it is eliminated.

However, older agreements are also still bringing in reductions. The 2008 New Zealand-China FTA included safeguards on imports of dairy products.[18] These safeguards implemented higher tariffs if imports exceeded certain quantities. Most of these have expired, with the final safeguard on whole and skim milk powders lifting at the end of 2023. We estimate this could save up to $219m each year compared to the year to April 2023.

The New Zealand-Thailand Closer Economic Partnership (CEP) is also due to deliver more tariff reductions for dairy.[19] By 2025, a full 20 years after the agreement came into force, tariff rate quotas on fluid milk and skim milk powders will be lifted. Skim milk powders are currently subject to a 210% tariff when out of quota, a prohibitive barrier that ensures the quota is binding. After 2025, these products will enjoy tariff free access to the Thai market.

Our existing trade agreements with Japan (under CPTPP) and Korea (Korea-New Zealand FTA) will likewise bring further tariff reductions over time. This includes the removal of tariff rate quotas on milk fats into Korea by 2024, and tariff free access for cheese into Japan by 2033. While many products will remain subject to tariff rate quotas, many of these will be lowered.

Non-tariff measures cost $7.8bn, the equivalent of 30% of Dairy exports

Research by Sense Partners on behalf of the Ministry of Foreign Affairs and Trade has analysed the impact of non-tariff measures on New Zealand's exports.[20] This research estimated that NTMs imposed a $5.4 billion cost on dairy products in 2019.

This amounted to 30.3% of exports in that year ($17.8 billion). Assuming a steady proportion, this may equate to a $7.8 billion cost in 2023.

Non-tariff measures include sanitary and phytosanitary measures (largely focused on food safety), technical regulations (like packaging requirements), licensing and paperwork, bans and prohibitions, and price controls, among many other requirements.

NTMs will typically impose some form of cost on exporters, though this cost will vary between markets and across products. However, certain NTMs may promote consumer confidence, such as by ensuring high food safety standards. This can lead to consumers paying more for more of our dairy exports. In this way, NTMs can be a boost to trade.

To give a sense of their prevalence, Table 5 below shows the average number of NTMs applied against New Zealand dairy exports for eight select product groupings in our top 10 markets. The count of NTMs by itself lacks important information about their actual impacts. As discussed above, some of these could be having a positive impact. China imposes the highest number of NTMs, on average, of our top 10 markets and yet is our largest market.

[18] Ministry of Foreign Affairs and Trade (2008) *NZ-China FTA: Annex 2: Special Agricultural Safeguard Measures*
[19] Ministry of Foreign Affairs and Trade (2005) *NZ-Thailand CEP Agreement: Annex 1.3: Tariff Quotas for Products under Category TRQ.*
[20] Sense Partners (2022) *Non-tariff measures: Impacts, trends, and effects on exports from New Zealand*.

TABLE 5: AVERAGE NUMBER OF NTMS APPLIED TO NZ DAIRY EXPORTS

Country	Whole milk powder	Skim milk powder	Butter & milkfats	Cheese	Casein & Caseinates	Whey protein concentrate	Condensed milk	Fluid milk
China	8.5	8.5	6.7	7.4	7.3	11.0	7.8	7.5
Indonesia	5.6	5.6	6.9	6.8	1.2	5.4	5.5	4.1
Australia	4.1	3.8	3.9	3.9	2.4	3.8	3.8	4.2
USA	8.5	7.7	6.7	8.5	2.7	7.4	8.7	7.8
Japan	3.0	2.6	2.8	2.7	3.3	2.1	3.1	2.6
Algeria	2.4	2.4	2.2	1.9	2.0	1.9	2.5	2.6
Malaysia	1.5	1.5	1.5	1.5	1.0	1.5	1.5	1.6
Thailand	3.6	3.5	4.9	5.1	1.7	2.2	3.5	3.2
Saudi Arabia	4.2	4.2	4.2	4.2	4.3	4.2	5.3	4.2
UAE	3.4	3.4	3.4	3.4	2.8	3.6	4.5	3.5

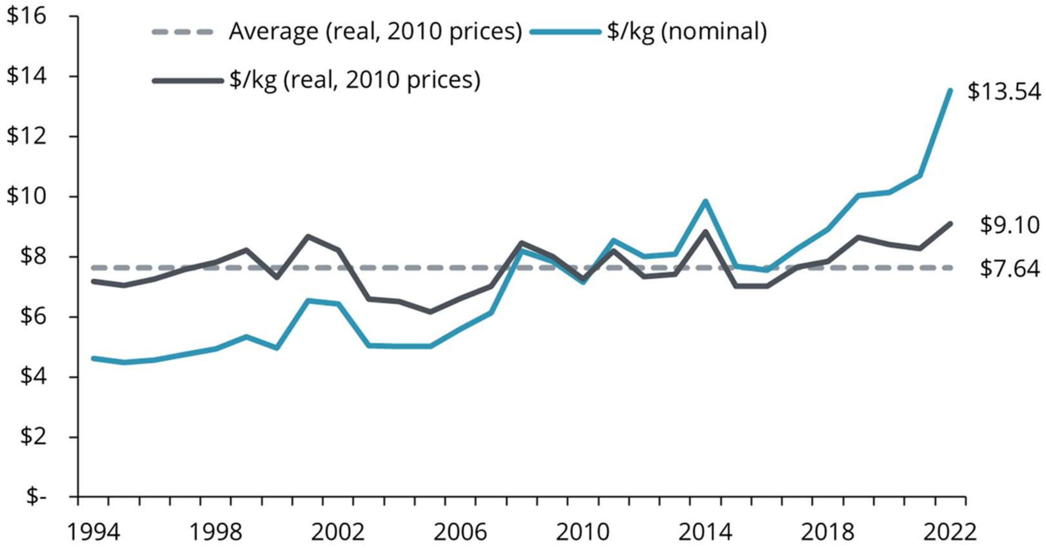
Source: UN TRAINS, Sense Partners

1.8. Trends in dairy exports

Despite inflation, real export value is rising

Figure 29 below shows export revenue dollars per kilogram of dairy milk solids produced in New Zealand. Nominal values, unadjusted for inflation, have increased rapidly since 2018, rising 51.8% from $8.92 to $13.54 per kg. While inflation, measured with the StatsNZ Dairy Cattle Farming PPI, has been high, real milk values are still rising. Real value per kg has risen 15.9% to $9.10 since 2018 and is sitting 19% above the long-term average of $7.64.

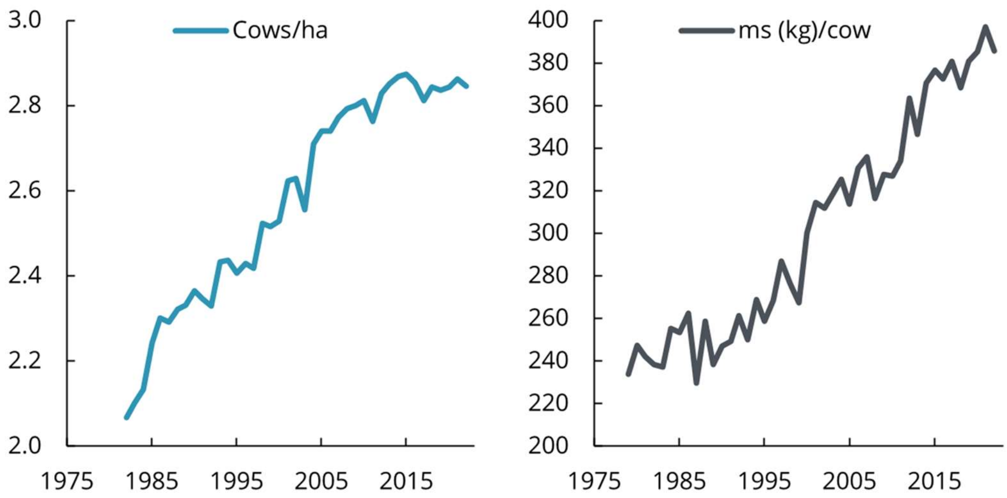
FIGURE 29: EXPORT REVENUE PER KG MILK SOLIDS PRODUCED, YEAR TO DECEMBER



Source: DCANZ, Statistics New Zealand, Sense Partners

Efficiency in the sector is decoupling value from the herd size

FIGURE 30: COWS PER HECTARE, AND MILK SOLIDS PER COW

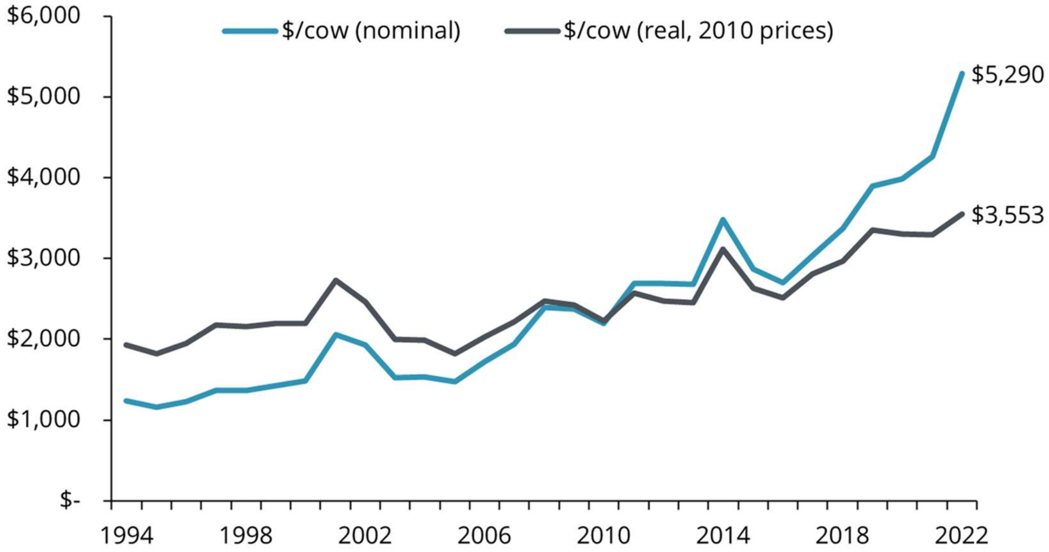


Source: Dairy NZ, Statistics New Zealand, Sense Partners

The number of dairy cows in the national herd peaked in 2015 at just over 5 million. Since then, it has fallen 3.5%. Likewise, the intensity of dairy farming, measured in cows per hectare, has flattened out at 2.85. Despite this, production per cow has continued to increase, rising an average 2.4% per annum between 2015 and 2022 to reach 386kg of milk solids per cow.

This has helped to drive an increase in real export value per cow. Nominal value per cow has risen 56.9% since 2018. Adjusted for inflation, real values have risen 19.7%.

FIGURE 31: EXPORT REVENUE PER COW, YEAR TO JUNE



Source: DCANZ, Statistics New Zealand, Sense Partners

2. Resilience

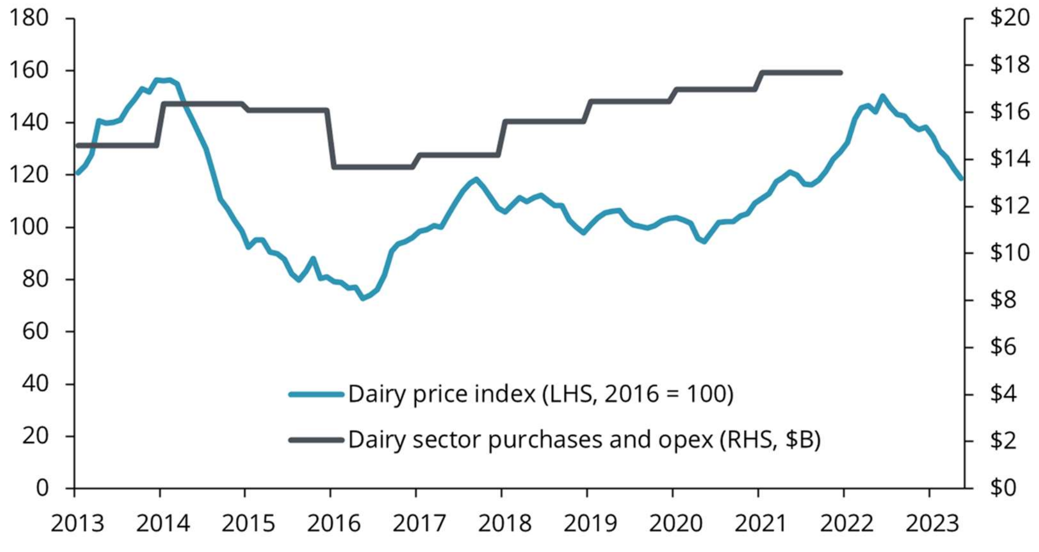
2.1. Dairy makes a foundational contribution

Dairy is exposed to global commodity cycles…

The standard deviation of the dairy price index, measured as a percentage of the index average, is 18.9%. This gives an indication of how volatile global dairy prices can be. For example, between February 2014 and May 2016, the index fell 53.5%.

This is partly due to the impacts of a surge in purchases and stockpiling in Asian markets in 2014, driving up prices. This was followed by a significant fall in purchases, as the stockpiling of 2014 was drawn down at the expense of new purchases. In addition, dairy export sanctions were applied against Russia after the occupation of Crimea.

FIGURE 32: DAIRY PRICE INDEX AND DAIRY SECTOR PURCHASES AND OPEX



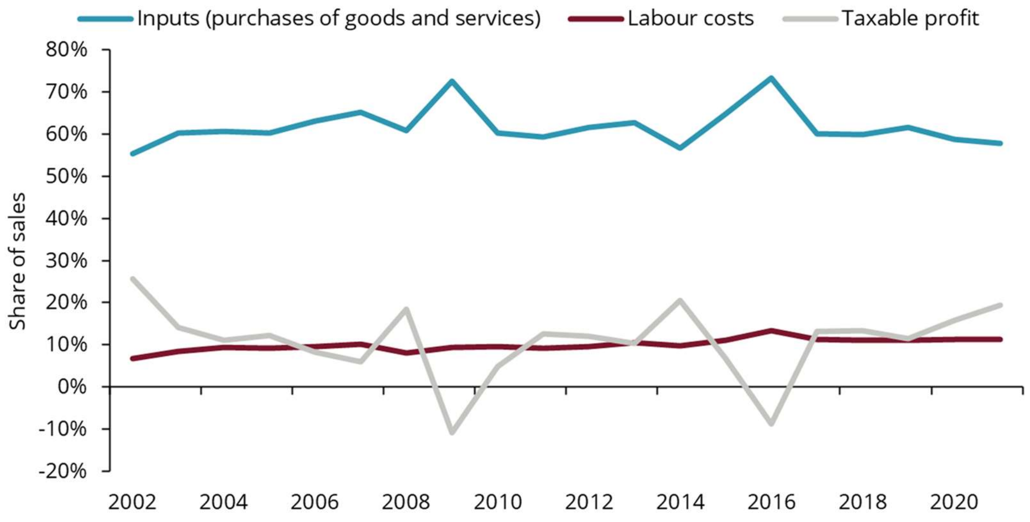
Source: FAO, Statistics New Zealand, Sense Partners

…yet purchases inputs at a steady pace, acting as a shock absorber

This volatility in dairy prices did not translate into a similar level of volatility in dairy economic activity. Dairy purchases and operating expenses remained relatively stable, with a standard deviation of 8%. While there inevitably is some impact from sharp falls in prices, dairy farmers must keep their farms running in the meantime. This means continued jobs and spending in the local economy. Indeed, total dairy sector purchases did not fall between 2017 and 2021.

Figure 33 below shows the share of dairy revenue directed to purchases of inputs, labour costs, and profit. The share directed to labour is relatively stable over time, between 8% and 13%. Bumper years have seen boosts to spending on inputs, but there is little downside in other years. It is taxable profit that takes the hit. This is where dairy farmers are absorbing the shock of milk price volatility, continuing to spend in the region and drive the local economy.

FIGURE 33: USE OF REVENUE – DAIRY SECTOR



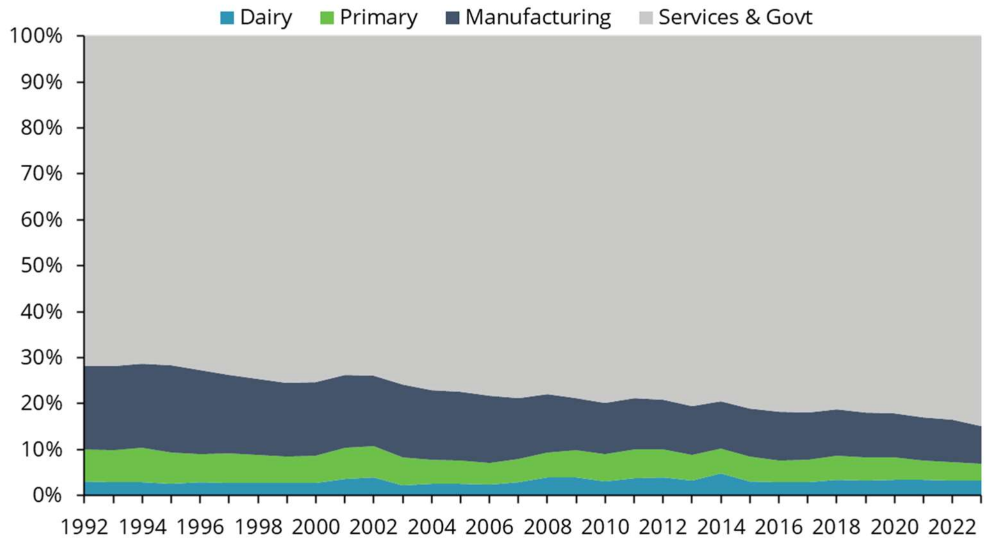
Source: Statistics New Zealand, Sense Partners

Dairy remains a long-term, steady foundation for the economy

Over the long term, the New Zealand economy has been transitioning toward services. Manufacturing's share of GDP has fallen from 18.2% in 1992 to just 8.1% in the year to March 2023, while services has risen from 71.8% to 84.9%. The primary sector as a whole has fallen from 10.1% to 7.0%. Yet dairy has retained its share, edging up from 3.1% to 3.2%.

While other components of the economy change over time, dairy remains a consistent share. This reflects our comparative advantage in the sector globally, and the success of dairy in growing export revenue, and providing sticky jobs with high median wages across the country.

FIGURE 34: SHARE OF GDP BY SECTOR, YEAR TO MARCH



Source: Statistics New Zealand, Sense Partners

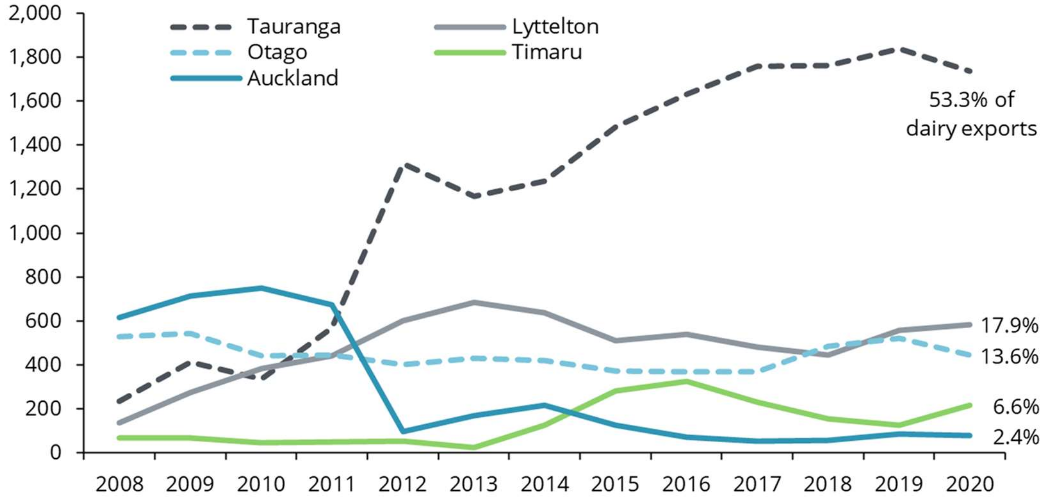
2.2. A resilient contribution needs resilient infrastructure

Achieving efficiency means investing in resilience

Almost all dairy exports are shipped by sea freight, making port infrastructure a key link in a competitive dairy supply chain. Tauranga is the primary export gateway for dairy, with 53.3% of dairy exports by weight moving through the port in 2020.

This has risen from just 14.9% in 2010 due to a reallocation of exports from Auckland to Tauranga. In 2010, 750,600 tonnes of dairy product were exported via Ports of Auckland, and 336,700 tonnes were exported via Port of Tauranga. Exports out of Auckland fell to just 77,800 tonnes in 2020, while those out of Tauranga rose to over 1.7m tonnes.

FIGURE 35: DAIRY EXPORTS, TOP 4 PORTS AND AUCKLAND, THOUSAND TONNES



Source: Ministry of Transport, Sense Partners

This is part of a global trend toward larger, more efficient ships. In 2021, 63% of container ships visiting NZ ports had a capacity of 4,000 TEU (twenty-foot equivalent unit) or more, up from just 2% in 2012. The Port of Tauranga is already servicing vessels with capacities up to 11,300 TEU, with the potential for up to 13,500 TEU vessels.[21]

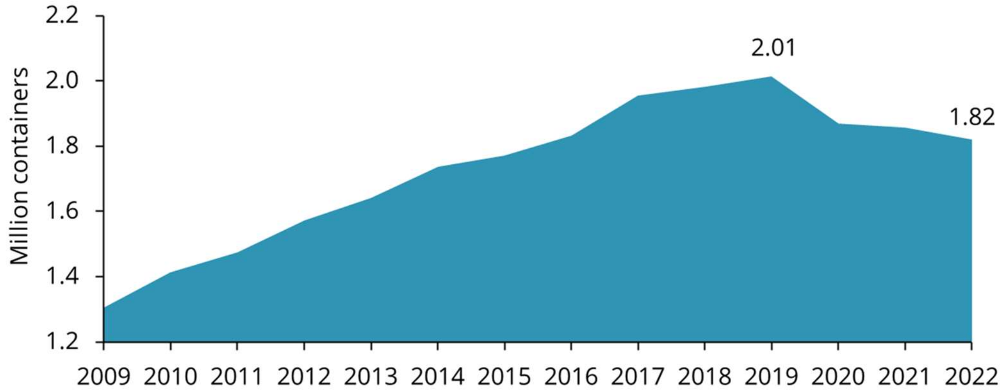
The economies of scale enabled by large vessels making fewer stops at more efficient ports helps to reduce shipping costs. These savings are important to ensure New Zealand exporters remain connected to, and competitive within, global markets.

Maintaining the infrastructure to service such large vessels in a few "backup" locations is likely to be cost prohibitive. This drives the focus toward investing in resilience in 'plant to ship' infrastructure, ensuring our most efficient ports are resilient to disruption.

[21] ANZ Research (2021) *NZ Insight: Freight challenges*

Recovering port productivity is essential to wider export performance

FIGURE 36: TOTAL CONTAINER THROUGHPUT OF NZ PORTS



Source: Ministry of Transport, Sense Partners

Due to the Covid-19 epidemic, the total number of containers processed by New Zealand ports fell 9.7% between 2019 and 2022, after strong growth through the prior decade. Figure 37 below shows ship handling rates for the three largest dairy export ports, and Auckland. Ship handling measures how many containers are moved on and off a ship each hour and indicates the overall productivity of the port.[22]

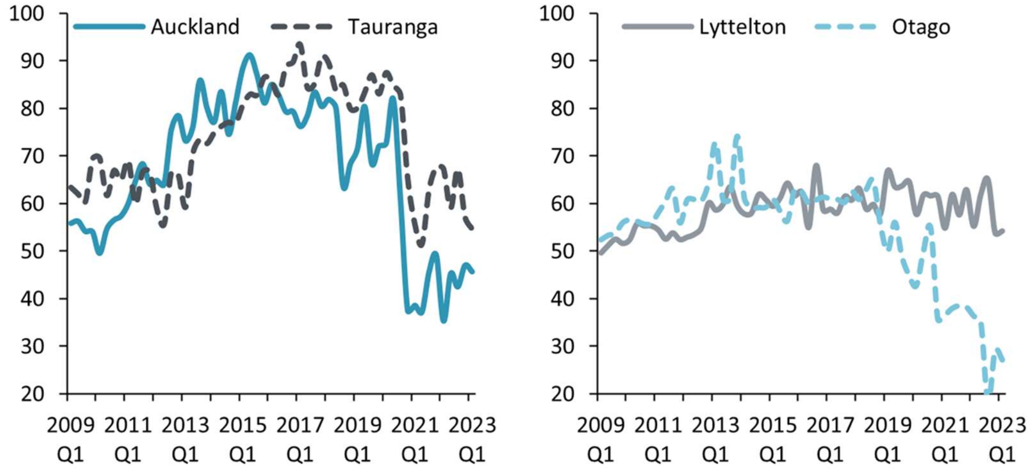
The Covid-19 pandemic triggered substantial falls in ship handling across most major ports, which have yet to recover. Much of this fall in productivity has been the result of a fall in the number of vessels visiting New Zealand ports. This was largely due to delays in major ports overseas causing ships to run behind schedule. Shipping companies opted to skip smaller destinations in order to make up for lost time.

Total container ship visits fell 31% between 2019 and 2022, with the highest fall (51%) in Port Chalmers (Otago). Visits to Timaru fell, 49%, Tauranga fell 22%, and those to Lyttelton fell 14%. Visits have yet to show any recovery since the pandemic disruption.

Almost all dairy exports leave the country via maritime shipping. The volume of milk produced is not expected to increase. However, growth in other export industries will start to challenge dairy for space on deck. Accommodating this growth, while preserving dairy exports at their current volume, will be a challenge without improvements in port efficiency.

[22] Ministry of Transport (2023) *Freight Information Gathering System: Port container handling*.

FIGURE 37: SHIP HANDLING RATES



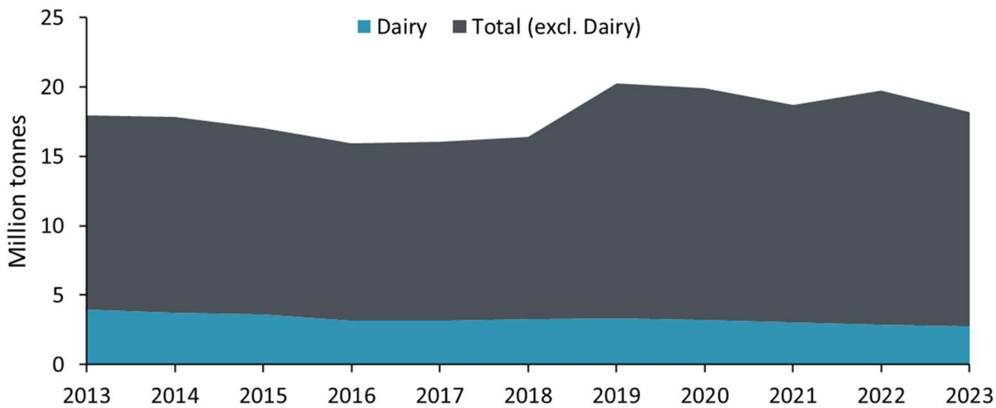
Source: Ministry of Transport, Sense Partners

Key rail links often lack a secondary route, pushing freight roadside

Resilience at the port of export is crucial. But this counts for little if access to the port itself is blocked off. Rail provides a potentially cost effective and environmentally friendly option to move dairy from the processing plant to the port.

However, where the main rail route is disrupted, the alternative is either road freight or no freight (i.e., lost production, missed or delayed shipments, and unhappy customers).

FIGURE 38: TOTAL FREIGHT MOVEMENTS BY RAIL, YEAR TO MARCH



Source: Ministry of Transport, Sense Partners

Rail access to the Port of Tauranga, the largest dairy export port in New Zealand, is reliant on a single rail line, the East Coast Main Trunk (ECMT). This is a particularly crucial link for dairy processors in Taranaki. Between 2019 and 2023, processors in the region experienced 9 rail outages of durations between 1 and 9 days.[23] Approximately 23% of total freight movements between Waikato and the Bay of Plenty are carried via rail on the ECMT.[24]

Switching even a portion of this to road could impose a large cost, particularly as trucks either have to cross up and over the Kaimai Range or detour north via SH2, incurring higher operating costs. Part of this increased cost would also come from having to compete with existing road freight customers in the event of an outage on one of the rail lines.

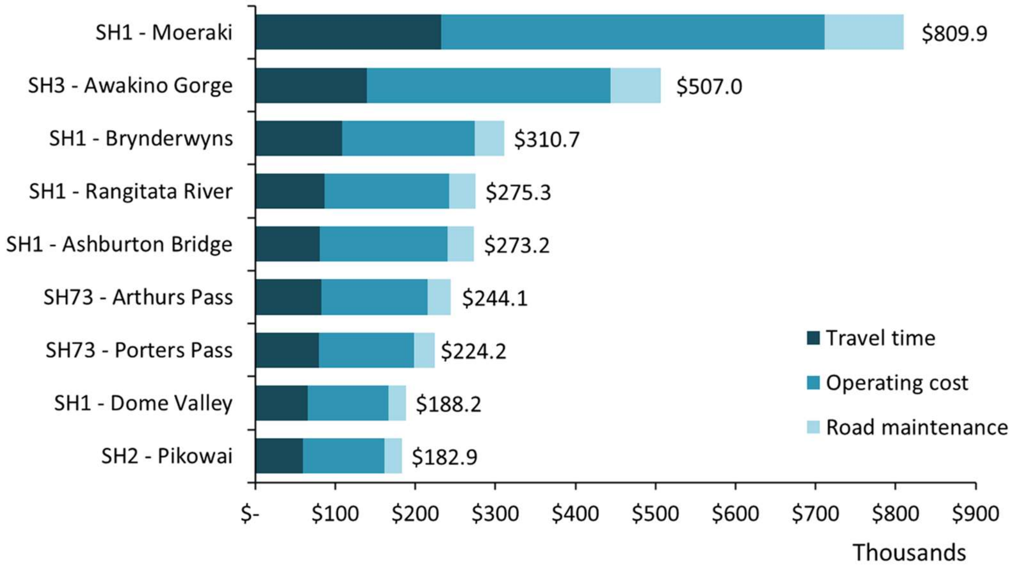
Despite rail's potential cost efficiency, it has been losing ground to road freight transport, particularly for dairy. The total volume of dairy products carried by rail has fallen 43% (1.2 million tonnes) since 2013.[25] An improvement in the cost efficiency of rail may help to reverse this trend, but consideration needs to be given to the resilience of the network.

The road network is vulnerable to costly closures on key routes

Liquid milk is typically processed within the region it is produced. Freight movements of liquid milk (all modes) tend to largely be within-region. The exception is Manawatu-Whanganui, which sends most (~82% in 2017/18) of its liquid milk to Taranaki.[26]

With farms dispersed across the countryside, milk tanker trucks are the only feasible option in transporting milk to the processing plant. These trucks rely on the rural road network, and the State Highway spine.

FIGURE 39: SHORT TERM FREIGHT COST IMPACT PER DAY OF ROUTE CLOSURE



Source: Waka Kotahi, Mobile Roads, Sense Partners

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[23] Information on rail outages supplied by DCANZ members
[24] Ministry of Transport (2019) *National Freight Demand Study 2017/18*. https://www.transport.govt.nz/assets/Uploads/Report/NFDS3-Final-Report-Oct2019-Rev1.pdf
[25] Ministry of Transport (2023) *Freight Information Gathering System.*
[26] Ministry of Transport (2019) *National Freight Demand Study 2017/18*. https://www.transport.govt.nz/assets/Uploads/Report/NFDS3-Final-Report-Oct2019-Rev1.pdf

A key issue facing this essential network is the relative vulnerability of rural road transport to disruption. There are many points where the network converges on chokepoints, with alternatives limited to long detours. In some areas, such as SH60 over Takaka Hill, or SH67 north of Westport, there are no alternatives at all.

DCANZ stakeholders have identified several key routes considered a risk. These are prone to disruption, and their alternatives come at a significant cost. Due to their commercially sensitive nature, these costs have not been provided for publication. However, we have used procedures and data from the Waka Kotahi Monetised Benefits and Costs Manual to estimate approximate cost impacts on total freight traffic arising from disruption to these routes.

We look at three main cost impacts: the value of freight travel time (including the driver's pay), the additional vehicle operating costs (such as fuel and maintenance), and additional road maintenance costs. We have used Road User Charges as a proxy for the additional road maintenance costs. The results are shown in in Figure 39 above.

This analysis only considers the upfront impact on transport and road maintenance costs. Consistent or repeated disruption on key routes may end up deterring investment and capping economic development over the longer term.

The cost is also based on present traffic volumes. For regions with poor roading infrastructure, such as the West Coast and Northland, historically weak transport infrastructure may have contributed to lower growth. The lower dollar cost on these routes, such as Arthurs Pass ($240,000) versus SH1 at Moeraki ($809,000), is in part the result of this lower past growth reflected in lower present truck traffic volumes.

For producers in remote areas, such as the West Coast, alternatives to some key routes may exceed 800km each way. Such a route is too costly to act as a feasible alternative. If the main route is closed, milk production is either diverted to other producers, or lost altogether.

Dairy export performance depends on reliable farm-to-port infrastructure

Reliable and resilient infrastructure is essential. Not only for export growth, but even to maintain our current export position, producers need to be able to get their products to customers. In a global supply chain that remains built around just-in-time delivery, reliably on-time delivery is key. The impacts of climate change are already testing the resilience of New Zealand's infrastructure.

Disruption to infrastructure may jeopardise our reputation as a reliable supplier, with negative implications for growing export value. Supply chains for both ambient temperature and refrigerated products are relevant to dairy. The ability to pivot the dairy product mix across either format is important for the industry to pursue added value opportunities.

We also need to avoid a tunnel-vision focus on the movement of processed products. The key input, fresh dairy milk off the farm, must be transported to the factory and processed within a few hours of milking. Achieving this is dependent on the road network: 11,000km of State Highways connecting 65,600km of rural roads.[27]

Ensuring this network is robust to disruption is a major challenge. However, it is a challenge that must be tackled. Resilient infrastructure is key to sustaining dairy production, exports, and the sector's foundational contribution to the New Zealand economy.

[27] Waka Kotahi (2023) *State Highway frequently asked questions.*

3. Appendices

Dairy GDP by region

TABLE 6: DAIRY GDP BY REGION

Region	Dairy GDP	Share of total GDP
Nelson	$19.4m	0.7%
Gisborne	$29.8m	1.0%
Marlborough	$58.7m	1.5%
Tasman	$96.0m	2.7%
Hawke's Bay	$137 m	1.3%
Wellington	$208 m	0.6%
West Coast	$339 m	14.4%
Northland	$594 m	5.4%
Bay of Plenty	$635 m	3.2%
Otago	$644 m	4.1%
Manawatu-Wanganui	$801 m	5.5%
Auckland	$915 m	0.8%
Southland	$953 m	13.8%
Taranaki	$976 m	12.0%
Canterbury	$1,945 m	4.6%
Waikato	$2,954 m	9.3%

Source: Statistics New Zealand, Sense Partners

Dairy jobs by district

TABLE 7: DAIRY JOBS BY DISTRICT (EXCLUDING SELF-EMPLOYED)

District	Farming jobs	Processing jobs	Share of total
Ashburton District	1750	6	10.5%
Auckland	350	1650	0.2%
Buller District	240	..	6.3%
Carterton District	120	..	3.8%
Central Hawke's Bay District	220	..	3.6%
Central Otago District	50	..	0.3%
Christchurch City	240	530	0.3%
Clutha District	750	530	14.5%
Dunedin City	190	3	0.3%
Far North District	360	21	1.8%

District	Farming jobs	Processing jobs	Share of total
Gisborne District	45	35	0.3%
Gore District	260	95	5.5%
Grey District	190	..	2.9%
Hamilton City	60	780	0.8%
Hastings District	100	55	0.3%
Hauraki District	520	40	9.2%
Horowhenua District	430	0	4.2%
Hurunui District	410	9	8.8%
Invercargill City	250	180	1.5%
Kaikoura District	55	..	3.8%
Kaipara District	460	140	8.6%
Kapiti Coast District	45	12	0.4%
Kawerau District	0	..	0.0%
Lower Hutt City	6	40	0.1%
Mackenzie District	110	..	5.4%
Manawatu District	520	3	5.2%
Marlborough District	95	9	0.4%
Masterton District	90	3	0.8%
Matamata-Piako District	1250	1150	15.5%
Napier City	0	6	0.0%
Nelson City	15	12	0.1%
New Plymouth District	490	6	1.3%
Opotiki District	130	..	3.4%
Otorohanga District	600	..	17.4%
Palmerston North City	110	510	1.1%
Porirua City	0	..	0.0%
Queenstown-Lakes District	45	9	0.2%
Rangitikei District	220	..	3.9%
Rotorua District	660	40	2.1%
Ruapehu District	85	..	1.5%
Selwyn District	1050	1050	10.0%
South Taranaki District	1500	1750	26.0%
South Waikato District	770	350	13.0%

District	Farming jobs	Processing jobs	Share of total
South Wairarapa District	170	6	5.4%
Southland District	2300	770	19.2%
Stratford District	250	..	7.8%
Tararua District	450	250	11.1%
Tasman District	290	120	1.7%
Taupo District	790	210	5.7%
Tauranga City	45	9	0.1%
Thames-Coromandel District	85	9	0.9%
Timaru District	670	960	6.5%
Upper Hutt City	3	..	0.0%
Waikato District	1050	330	6.3%
Waimakariri District	470	12	2.7%
Waimate District	470	400	33.5%
Waipa District	900	630	7.0%
Wairoa District	18	..	0.5%
Waitaki District	650	130	7.3%
Waitomo District	200	..	4.8%
Wellington City	0	12	0.0%
Western Bay of Plenty District	350	3	1.9%
Westland District	240	550	22.3%
Whakatane District	450	360	5.7%
Whanganui District	95	30	0.7%
Whangarei District	420	380	2.1%

Source: Statistics New Zealand, Sense Partners

Dairy wages by district

TABLE 8: DAIRY WAGES BY DISTRICT

District	Farming wages	Processing wages	Share of total
Ashburton District	$93.9m	$0.9m	9.8%
Auckland	$18.8m	$237.9m	0.4%
Buller District	$12.9m	$0.0m	6.1%
Carterton District	$6.4m	$0.0m	3.9%
Central Hawke's Bay District	$11.8m	$0.0m	3.9%
Central Otago District	$2.7m	$0.0m	0.4%
Christchurch City	$12.9m	$76.4m	0.6%
Clutha District	$40.2m	$76.4m	24.2%
Dunedin City	$10.2m	$0.4m	0.3%
Far North District	$19.3m	$3.0m	2.1%
Gisborne District	$2.4m	$5.0m	0.6%
Gore District	$14.0m	$13.7m	8.3%
Grey District	$10.2m	$0.0m	2.5%
Hamilton City	$3.2m	$112.5m	1.7%
Hastings District	$5.4m	$7.9m	0.5%
Hauraki District	$27.9m	$5.8m	10.1%
Horowhenua District	$23.1m	$0.0m	4.3%
Hurunui District	$22.0m	$1.3m	10.0%
Invercargill City	$13.4m	$26.0m	2.3%
Kaikoura District	$3.0m	$0.0m	4.1%
Kaipara District	$24.7m	$20.2m	11.7%
Kapiti Coast District	$2.4m	$1.7m	0.5%
Kawerau District	$0.0m	$0.0m	0.0%
Lower Hutt City	$0.3m	$5.8m	0.2%
Mackenzie District	$5.9m	$0.0m	5.4%
Manawatu District	$27.9m	$0.4m	5.1%
Marlborough District	$5.1m	$1.3m	0.5%
Masterton District	$4.8m	$0.4m	0.9%
Matamata-Piako District	$67.1m	$165.8m	24.4%
Napier City	$0.0m	$0.9m	0.1%

District	Farming wages	Processing wages	Share of total
Nelson City	$0.8m	$1.7m	0.2%
New Plymouth District	$26.3m	$0.9m	1.1%
Opotiki District	$7.0m	$0.0m	3.8%
Otorohanga District	$32.2m	$0.0m	16.2%
Palmerston North City	$5.9m	$73.5m	2.4%
Porirua City	$0.0m	$0.0m	0.0%
Queenstown-Lakes District	$2.4m	$1.3m	0.3%
Rangitikei District	$11.8m	$0.0m	4.4%
Rotorua District	$35.4m	$5.8m	2.2%
Ruapehu District	$4.6m	$0.0m	1.5%
Selwyn District	$56.3m	$151.4m	16.9%
South Taranaki District	$80.5m	$252.3m	41.4%
South Waikato District	$41.3m	$50.5m	17.0%
South Wairarapa District	$9.1m	$0.9m	6.6%
Southland District	$123.4m	$111.0m	28.0%
Stratford District	$13.4m	$0.0m	8.3%
Tararua District	$24.1m	$36.0m	20.1%
Tasman District	$15.6m	$17.3m	2.7%
Taupo District	$42.4m	$30.3m	7.3%
Tauranga City	$2.4m	$1.3m	0.1%
Thames-Coromandel District	$4.6m	$1.3m	1.2%
Timaru District	$36.0m	$138.4m	12.1%
Upper Hutt City	$0.2m	$0.0m	0.0%
Waikato District	$56.3m	$47.6m	8.1%
Waimakariri District	$25.2m	$1.7m	3.0%
Waimate District	$25.2m	$57.7m	52.0%
Waipa District	$48.3m	$90.8m	11.4%
Wairoa District	$1.0m	$0.0m	0.6%
Waitaki District	$34.9m	$18.7m	9.0%
Waitomo District	$10.7m	$0.0m	5.0%
Wellington City	$0.0m	$1.7m	0.0%
Western Bay of Plenty District	$18.8m	$0.4m	1.8%
Westland District	$12.9m	$79.3m	43.9%

District	Farming wages	Processing wages	Share of total
Whakatane District	$24.1m	$51.9m	9.2%
Whanganui District	$5.1m	$4.3m	0.9%
Whangarei District	$22.5m	$54.8m	3.3%

Source: Statistics New Zealand, Sense Partners

Estimated Dairy GDP by Territorial Authority

TABLE 9: ESTIMATED DAIRY GDP BY TERRITORIAL AUTHORITY

Territorial Authority	Dairy GDP	Share
Far North District	$ 144.6 m	4.2%
Whangarei District	$ 241.3 m	3.8%
Kaipara District	$ 207.9 m	17.8%
Auckland	$ 919.2 m	0.8%
Thames-Coromandel District	$ 29.6 m	1.9%
Hauraki District	$ 177.6 m	19.7%
Waikato District	$ 415.6 m	12.9%
Matamata-Piako District	$ 667.6 m	29.1%
Hamilton City	$ 197.5 m	1.3%
Waipa District	$ 435.4 m	13.4%
Otorohanga District	$ 194.4 m	38.1%
South Waikato District	$ 329.4 m	25.9%
Waitomo District	$ 64.8 m	10.6%
Taupo District	$ 303.9 m	11.8%
Western Bay of Plenty District	$ 150.4 m	5.4%
Tauranga City	$ 22.0 m	0.2%
Rotorua District	$ 294.1 m	6.1%
Whakatane District	$ 302.8 m	14.4%
Kawerau District	$ -	0.0%
Opotiki District	$ 55.5 m	9.8%
Gisborne District	$ 29.9 m	0.9%
Wairoa District	$ 5.7 m	1.2%
Hastings District	$ 54.5 m	0.8%
Napier City	$ 2.5 m	0.1%
Central Hawke's Bay District	$ 69.7 m	8.4%
New Plymouth District	$ 148.6 m	2.7%
Stratford District	$ 75.3 m	16.5%
South Taranaki District	$ 755.6 m	42.4%

Ruapehu District	$ 26.7 m	3.5%
Whanganui District	$ 37.8 m	1.4%
Rangitikei District	$ 69.0 m	8.8%
Manawatu District	$ 163.9 m	11.7%
Palmerston North City	$ 169.7 m	2.2%
Tararua District	$ 207.4 m	23.6%
Horowhenua District	$ 134.9 m	9.4%
Kapiti Coast District	$ 25.1 m	1.3%
Porirua City	$ -	0.0%
Upper Hutt City	$ 1.1 m	0.1%
Lower Hutt City	$ 33.3 m	0.5%
Wellington City	$ 9.4 m	0.0%
Masterton District	$ 33.9 m	2.1%
Carterton District	$ 42.0 m	10.0%
South Wairarapa District	$ 64.2 m	15.1%
Tasman District	$ 96.5 m	2.5%
Nelson City	$ 19.5 m	0.6%
Marlborough District	$ 59.0 m	1.4%
Kaikoura District	$ 14.1 m	7.2%
Buller District	$ 77.5 m	12.3%
Grey District	$ 61.4 m	5.6%
Westland District	$ 199.1 m	33.8%
Hurunui District	$ 106.9 m	16.6%
Waimakariri District	$ 122.9 m	5.2%
Christchurch City	$ 166.9 m	0.6%
Selwyn District	$ 478.1 m	16.7%
Ashburton District	$ 450.0 m	19.9%
Timaru District	$ 362.7 m	10.8%
Mackenzie District	$ 28.2 m	10.2%
Waimate District	$ 200.1 m	56.8%
Waitaki District	$ 192.6 m	13.3%

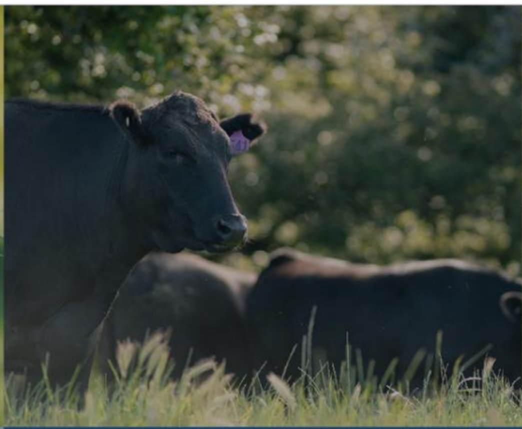
Central Otago District	$ 16.4 m	0.8%
Queenstown-Lakes District	$ 16.6 m	0.5%
Dunedin City	$ 62.9 m	0.7%
Clutha District	$ 354.7 m	28.7%
Southland District	$ 759.8 m	34.7%
Gore District	$ 87.3 m	10.0%
Invercargill City	$ 99.5 m	2.5%

Source: Statistics New Zealand, Sense Partners

SENSE PARTNERS

DATA LOGIC ACTION

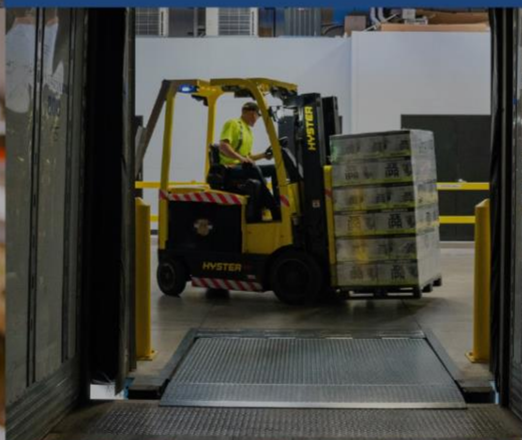
Appendix 2B: Economic Contribution of the New Zealand red meat industry, June 2020

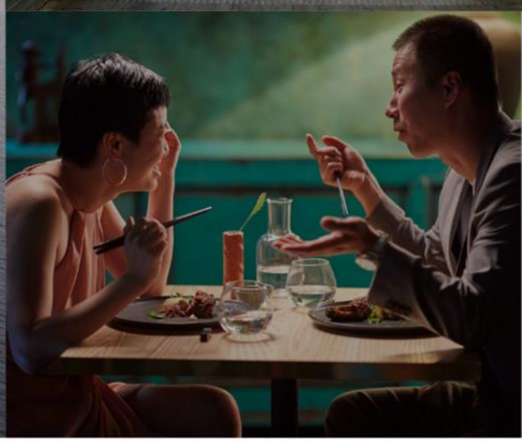


Economic contribution of the New Zealand red meat industry

Full Report

June 2020





Contents

Executive Summary

The Meat Industry Association (MIA) in conjunction with Beef + Lamb New Zealand Ltd (B+LNZ) commissioned an economic contribution assessment of the red meat industry, including production, processing and exporting, examined individually and collectively. This report provides the results of that analysis.

The availability of aggregated private data covering both sectors (for B+LNZ in the form of Sheep and Beef Farm Surveys and for MIA from the previously conducted cost analysis exercise), to augment public data, provides a unique opportunity for such an analysis.

The economic contribution of the red meat industry (i.e. livestock production and red meat processing and exporting in aggregate) on New Zealand as a whole is summarised in the table below.

Economic contribution of the red meat industry, New Zealand, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	35,702	3,775	1,477
Flow-on contribution	56,719	8,197	3,124
Total contribution	92,421	11,973	4,601
As % of New Zealand	4.7%	4.2%	4.0%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The red meat industry accounts for over 92,000 jobs, nearly $12 billion in industry value added and $4.6 billion in household income, including flow on effects. It accounts for 4.7 per cent of total national employment and over 4 per cent of national industry value added and household income when flow-on effects are taken into account. Whilst the contribution to the national economy in absolute terms is obviously very substantial, it might be thought that the percentage contribution is small. However, this would not be correct.

In order to provide context for this analysis, one should note that in most developed countries, the tertiary or service sector contributes around 80 per cent of national industry value added, and New Zealand is no exception. The following table provides a summary distribution of industry value added by industry for the year ending March 2018, and indicates that the tertiary sector contributes around 81 per cent and primary and secondary sectors contribute around 19 per cent of gross industry value added in New Zealand.

In order to prevent double counting, it is best to compare direct contributions to national value added without flow-on effects. On that basis, the red meat sector contributes directly around 1.4 per cent to national industry value added. This means it contributes fully 7.7 per cent of all national non-tertiary value added.

Contribution to Gross Industry Value Added by industry, New Zealand, 2017-18

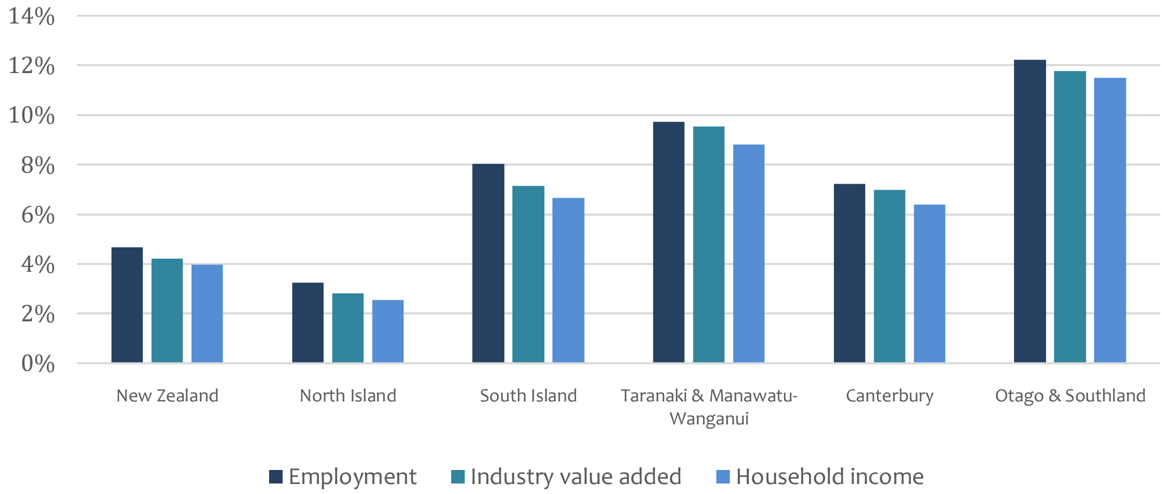
	2018	
	$ million	% of total
Agriculture	12,431	4.7%
Forestry and logging	1,910	0.7%
Fishing, aquaculture and agriculture, forestry and fishing support services	2,470	0.9%
Mining	2,883	1.1%
Food, beverage and tobacco product manufacturing	10,602	4.0%
Textile, leather, clothing and footwear manufacturing	674	0.3%
Wood and paper products manufacturing	2,288	0.9%
Printing	681	0.3%
Petroleum, chemical, polymer and rubber product manufacturing	5,452	2.1%
Non-metallic mineral product manufacturing	1,210	0.5%
Metal product manufacturing	3,044	1.2%
Transport equipment, machinery and equipment manufacturing	4,897	1.9%
Furniture and other manufacturing	767	0.3%
Electricity, gas, water and waste services	8,026	3.0%
Construction	18,540	7.0%
Wholesale trade	14,202	5.4%
Retail trade	12,998	4.9%
Accommodation and food services	6,360	2.4%
Transport, postal, and warehousing	13,012	4.9%
Information media and telecommunications	6,777	2.6%
Financial and insurance services	16,973	6.4%
Rental, hiring, and real estate services	21,171	8.0%
Owner-occupied property operation	18,321	6.9%
Professional, scientific, and technical services	23,152	8.8%
Administrative and support services	5,681	2.1%
Local government administration	1,374	0.5%
Central government administration, defence, and public safety	10,157	3.8%
Education and training	12,258	4.6%
Health care and social assistance	16,843	6.4%
Arts and recreation services	3,853	1.5%
Other services	5,314	2.0%
Total all industries	264,323	100.0%
Primary industry sector	19,694	7.5%
Secondary industry sector	29,615	11.2%
Tertiary industry sector	215,012	81.3%

Source: SNZ data

As noted above, at the national level, the red meat processing sector contributes approximately 4.7 percent of FTE employment and 4.2 percent of industry value added when flow-on effects are taken into account. The top sector benefitting from flow-on employment impacts is agriculture, and these impacts predominantly flow to the dairy cattle farming sector.

However, the magnitude of the contribution is more pronounced at the regional level as illustrated in the figure below. In Otago and Southland for example, the industry's contribution is around 12 per cent of employment, industry value added and household income, which is very substantial indeed.

Contribution of the red meat industry in total (including flow-on effects) to the relevant economy, 2017-18



1.0 Introduction

SG Heilbron Economic & Policy Consulting (SGH or the Consultants) has previously prepared a report for the Meat Industry Association (MIA) examining the costs to operate and associated regulatory components in the red meat processing sector[1]. The report recommended, inter alia, that the industry undertake an economic contribution analysis, utilising the data provided by processors, to inform governments and other stakeholders about the economic contribution of the industry and provide the information necessary to support the effective dissemination of the costs competitiveness work.

Accordingly, MIA in conjunction with Beef + Lamb New Zealand Ltd (B+LNZ) commissioned the consultants to conduct an economic contribution assessment of the red meat industry, including production, processing and exporting, examined individually and collectively. This report provides the results of that analysis.

2.0 Understanding of the task

The New Zealand Meat Industry Association (MIA) and Beef + Lamb New Zealand (B+LNZ) commissioned an economic contribution assessment covering both beef and lamb (and to a lesser extent, deer) production, processing and exporting. The availability of aggregated private data covering both sectors (for B+LNZ in the form of producer surveys and for MIA from the previously conducted cost analysis exercise), to augment public data, provides a unique opportunity for such an analysis, with the resulting analysis benefitting from the authenticity of the data and facilitating 'buy in' from producers and processors in the dissemination of the results of such through-chain collaboration.

The MIA and B+LNZ required the research to achieve the following outcomes:

1. An analysis that identifies the economic contribution of the beef and sheepmeat production, processing and exporting industries in 2017-18.
2. Identifies the economic contribution of the industries, both separately and combined, in direct terms and with flow-on effects, in relation to the metrics of employment (measured as full-time equivalent (FTE) positions), industry value added and household income.
3. The contributions are identified at national, island levels and for three selected regions[2].

[1] Meat Processing and Regulatory Costs – July 2019. SG Heilbron Economic & Policy Consulting

[2] It should be noted that the original proposal for this Project nominated four regions, namely Taranaki, Manawatu-Wanganui, Canterbury and Southland. However, this was amended to ensure that slaughter numbers for the assessment of the processing sector could be scaled up to reflect data published by Statistics New Zealand. Accordingly, the regional results now reflect three regions, namely: Taranaki & Manawatu-Wanganui combined, Canterbury, and Otago & Southland combined.

4. Produce a report outlining the methodology and results.

3.0 Methodology

The methodology to undertake the economic contribution assessment is summarised as follows:

- Development of the relevant input output (IO) tables for 2017-18. The IO tables were constructed using a range of data available from Statistics New Zealand (SNZ).
- Analysis of primary data regarding livestock production. B+LNZ supplied data from its Sheep and Beef Farm Survey for each of the geographical regions. That data was analysed to concord with IO categories for expenditure and income.
- Analysis of primary data relating to red meat processing. Aggregated data provided by red meat processing facilities for the previously mentioned cost to operate study was analysed by animal type, scaled up using data from SNZ relating to slaughter numbers to reflect the total sector and allocated to the relevant IO categories. The existing data was augmented by supplementary information from processors regarding the proportion of expenditure made within and outside the relevant region for sub-national IO tables.
- Insertion of a new sector into the IO tables reflecting either livestock production or red meat processing, with the new sectors then being subtracted from the relevant "parent" sector already in the table (*Agriculture* in the case of livestock production and *Meat and Meat Product Manufacturing* in the case of red meat processing).
- Assessment of the economic contribution of each of livestock production and red meat processing for each geographical area in terms of employment (FTEs), industry value added and household income, including both direct and flow-on impacts.
- Aggregation of the livestock production and red meat processing and exporting sectors in the IO tables to create a red meat industry sector and calculation of the economic contribution of that resultant sector.

A more detailed description of the Methodology is provided in Appendix 1 of this report.

4.0 Economic contribution of the livestock production sector

The economic contribution of the livestock production sector reflects expenditure made by farms in the production of beef cattle, sheep and, to a lesser extent deer, which form a relatively small proportion of the sector. It should be noted that data on farms provided by B+LNZ also incorporates other aspects of production including, for example, crop growing, wool production and revenue derived from grazing of dairy cattle. For this reason, not the expenditure measured can be directly attributed to that associated with the production of cattle, sheep and deer. Data on expenditure in the livestock production sector does not necessarily align directly with the categories in the IO table. The distribution of the proportion of expenditure for each of these across the relevant IO categories was reviewed in conjunction with representatives from B+LNZ. This is addressed in more detail in Appendix 1 of this report.

The economic contribution of the livestock production sector by geographical region is summarised below.

4.1 Economic contribution – New Zealand

The economic contribution of the livestock production sector on New Zealand as a whole is summarised in Table 4.1.

Table 4.1: Economic contribution of livestock production, New Zealand, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	16,040	2,129	346
Flow-on contribution	27,745	4,130	1,649
Total contribution	43,785	6,259	1,994
As % of New Zealand	2.2%	2.2%	1.7%

Source: SGH estimates using B+LNZ and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the livestock production sector supports approximately 2.2 percent of the FTE workforce in New Zealand, with 16,040 FTEs being employed directly and a further 27,745 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow on employment impacts are, in descending order of significance:

- Agricultural support services (5,390 FTEs or 21.2% of total employed in the sector);
- Financial & insurance services (2,490 FTEs or 3.7% of total employed in the sector);
- Public administration & defence (2,140 FTEs or 1.9% of total employed in the sector);
- Basic material wholesaling (1,300 FTEs or 6.3% of total employed in the sector);
- Agriculture (1,140 FTEs or 1.2% of total employed in the sector); and
- Health care & social assistance (1,010 FTEs or 0.5% of total employed in the sector).

It should be noted that the flow-on impacts include both industrial support and consumption induced effects as defined in Appendix 1 – Estimating economic contributions. It is the latter effect which results in *health care & social assistance* ranking in the top six sectors.

Industry value added

The livestock production sector is also estimated to contribute approximately 2.2 percent of New Zealand's industry value added when flow-on effects are taken into account. This equates to approximately NZ$2.1 billion in direct effects and NZ$4.1 billion in flow-on impacts. The top six sectors benefitting from flow on industry value added impacts, in descending order of significance, are:

- Financial & insurance services;
- Agricultural support services;
- Rental, hiring & real estate;
- Owner-occupied property operation;
- Basic material wholesaling; and
- Fertiliser & pesticide manufacturing.

Household income

Finally, the livestock production sector is estimated to contribute approximately 1.7 percent of national household income, equating to almost NZ$2 billion in 2017-18. As a result of relatively low compensation of employees in the sector, combined with owners reportedly being remunerated from gross operating surplus (gross profit before depreciation and tax), almost 83 percent of the household income impacts are derived from flow-on effects.

4.2 Economic contribution – North Island

The economic contribution of the livestock production sector on the North Island is summarised in Table 4.2.

Table 4.2: Economic contribution of livestock production, North Island, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	8,330	1,107	191
Flow-on contribution	12,158	1,858	763
Total contribution	20,488	2,965	954
As % of North Island	1.4%	1.3%	1.0%

Source: SGH estimates using B+LNZ and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the livestock production sector supports approximately 1.4 percent of the FTE workforce in the North Island, with approximately 8,300 FTEs being employed directly and a further 12,200 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agricultural support services (2,250 FTEs or 13.6% of total employed in the sector);
- Financial & insurance services (1,170 FTEs or 2.1% of total employed in the sector);

- Public administration & defence (940 FTEs or 1.0% of total employed in the sector);
- Basic material wholesaling (560 FTEs or 3.6% of total employed in the sector);
- Health care & social assistance (450 FTEs or 0.3% of total employed in the sector); and
- Agriculture (410 FTEs or 0.7% of total employed in the sector).

Industry value added

The livestock production sector is also estimated to contribute approximately 1.3 percent of the North Island's industry value added when flow-on effects are taken into account. This equates to approximately NZ$1.1 billion in direct effects and NZ$1.9 billion in flow-on impacts. The top six sectors benefitting from flow on industry value added impacts are, in descending order of significance:

- Financial & insurance services;
- Agricultural support services;
- Rental, hiring & real estate;
- Owner-occupied property operation;
- Fertiliser & pesticide manufacturing; and
- Public administration & defence.

Household income

Finally, the livestock production sector is estimated to contribute approximately 1.0 percent of household income in the North Island, equating to almost NZ$1 billion in 2017-18. As a result of relatively low compensation of employees in the sector, combined with owners reportedly being remunerated from gross operating surplus, almost 80 percent of the household income impacts are derived from flow-on effects.

4.3 Economic contribution – South Island

The economic contribution of the production sector on the South Island is summarised in Table 4.3.

Table 4.3: Economic contribution of livestock production, South Island, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	7,710	1,022	155
Flow-on contribution	12,265	1,600	671
Total contribution	19,975	2,622	826
As % of South Island	4.1%	4.1%	3.0%

Source: SGH estimates using B+LNZ and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the livestock production sector supports approximately 4.1 percent of the FTE workforce in the South Island, with approximately 7,700 FTEs being employed directly and a further approximately 20,000 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agricultural support services (2,830 FTEs or 32.1% of total employed in the sector);
- Financial & insurance services (1,090 FTEs or 10.3% of total employed in the sector);
- Public administration & defence (770 FTEs or 3.8% of total employed in the sector);
- Agriculture (680 FTEs or 1.9% of total employed in the sector);
- Basic material wholesaling (680 FTEs or 12.5% of total employed in the sector); and
- Other wholesaling (400 FTEs or 3.7% of total employed in the sector).

Industry value added

The livestock production sector is also estimated to contribute approximately 4.1 percent of the South Island's industry value added when flow-on effects are taken into account. This equates to approximately NZ$1.0 billion in direct effects and NZ$1.6 billion in flow-on impacts. The top six sectors benefitting from flow on industry value added impacts are, in descending order of significance:

- Financial & insurance services;
- Agricultural support services;
- Rental, hiring & real estate;
- Owner-occupied property operation;
- Basic material wholesaling; and
- Public administration & defence.

Household income

Finally, the livestock production sector is estimated to contribute approximately 3.0 percent of household income in the South Island, equating to more than NZ$0.8 billion in 2017-18. As a result of relatively low compensation of employees in the sector, combined with owners reportedly being remunerated from gross operating surplus, more than 81 percent of the household income impacts are derived from flow-on effects.

4.4 Economic contribution – Taranaki & Manawatu-Wanganui combined

The economic contribution of the livestock production sector on the combined Regional Council areas of Taranaki and Manawatu-Wanganui is summarised in Table 4.4.

Table 4.4: Economic contribution of livestock production, Taranaki & Manawatu-Wanganui combined, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	1,960	236	46
Flow-on contribution	3,968	599	205
Total contribution	5,928	835	251
As % of Taranaki & Manawatu-Wanganui combined	4.3%	4.4%	3.4%

Source: SGH estimates using B+LNZ and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the livestock production sector supports approximately 4.3 percent of the FTE workforce in the combined Regional Council areas of Taranaki and Manawatu-Wanganui, with approximately 1,960 FTEs being employed directly and a further almost 4,000 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (510 FTEs or 4.1% of total employed in the sector);
- Agricultural support services (480 FTEs or 21.2% of total employed in the sector);
- Financial & insurance services (320 FTEs or 11.4% of total employed in the sector);
- Public administration & defence (220 FTEs or 2.2% of total employed in the sector);
- Health care & social assistance (180 FTEs or 1.2% of total employed in the sector); and
- Basic material wholesaling (170 FTEs or 11.1% of total employed in the sector).

Industry value added

The livestock production sector is also estimated to contribute approximately 4.4 percent of the industry value added in the combined Regional Council areas of Taranaki and Manawatu-Wanganui when flow-on effects are taken into account. This equates to approximately NZ$0.24 billion in direct effects and NZ$0.6 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture;
- Financial & insurance services;
- Agricultural support services;
- Rental, hiring & real estate;
- Owner-occupied property operation; and

- Public administration & defence.

Household income

Finally, the livestock production sector is estimated to contribute approximately 3.4 percent of household income in the combined Regional Council areas of Taranaki and Manawatu-Wanganui, equating to approximately NZ$0.25 billion in 2017-18. As a result of relatively low compensation of employees in the sector, combined with owners reportedly being remunerated from gross operating surplus, almost 82 percent of the household income impacts are derived from flow-on effects.

4.5 Economic contribution – Canterbury

The economic contribution of the livestock production sector on the Canterbury Regional Council (Environment Canterbury) area is summarised in Table 4.5.

Table 4.5: Economic contribution of livestock production, Canterbury, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	3,860	569	108
Flow-on contribution	10,025	1,333	500
Total contribution	13,885	1,902	609
As % of Canterbury	5.2%	5.4%	4.3%

Source: SGH estimates using B+LNZ and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the livestock production sector supports approximately 5.2 percent of the FTE workforce in the Canterbury Regional Council area, with approximately 3,860 FTEs being employed directly and more than 10,000 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (1,600 FTEs or 11.4% of total employed in the sector);
- Agricultural support services (1,450 FTEs or 49.3% of total employed in the sector);
- Financial & insurance services (790 FTEs or 12.6% of total employed in the sector);
- Public administration & defence (560 FTEs or 4.8% of total employed in the sector);
- Basic material wholesaling (520 FTEs or 15.6% of total employed in the sector); and
- Health care & social assistance (360 FTEs or 1.4% of total employed in the sector).

Industry value added

The livestock production sector is also estimated to contribute approximately 5.4 percent of the industry value added in the Canterbury Regional Council area when flow-on effects are taken into account. This equates to approximately NZ$0.57 billion in direct effects and NZ$1.3 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Financial & insurance services;
- Agriculture;
- Rental, hiring & real estate;
- Agricultural support services;
- Owner-occupied property operation; and
- Basic material wholesaling.

Household income

Finally, the livestock production sector is estimated to contribute approximately 4.3 percent of household income in the Canterbury Regional Council area, equating to approximately NZ$0.6 billion in 2017-18. As a result of relatively low compensation of employees in the sector, combined with owners reportedly being remunerated from gross operating surplus, more than 82 percent of the household income impacts are derived from flow-on effects.

4.6 Economic contribution – Otago & Southland combined

The economic contribution of the production sector on the combined Regional Council areas of Otago and Southland is summarised in Table 4.6.

Table 4.6: Economic contribution of red meat production, Otago & Southland combined, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	3,200	484	53
Flow-on contribution	6,765	824	305
Total contribution	9,965	1,308	358
As % of Otago & Southland combined	6.9%	7.1%	5.1%

Source: SGH estimates using B+LNZ and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the livestock production sector supports approximately 6.9 percent of the FTE workforce in the combined Regional Council areas of Otago and Southland, with approximately 3,200 FTEs being employed directly and almost 6,800 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow on employment impacts are, in descending order of significance:

- Agricultural support services (1,450 FTEs or 39.1% of total employed in the sector);
- Agriculture (930 FTEs or 6.3% of total employed in the sector);
- Financial & insurance services (480 FTEs or 15.4% of total employed in the sector);
- Public administration & defence (370 FTEs or 6.2% of total employed in the sector);
- Basic material wholesaling (280 FTEs or 19.3% of total employed in the sector); and
- Health care & social assistance (210 FTEs or 1.5% of total employed in the sector).

Industry value added

The livestock production sector is also estimated to contribute approximately 7.1 percent of the industry value added in the combined Regional Council areas of Otago and Southland when flow-on effects are taken into account. This equates to approximately NZ$0.48 billion in direct effects and NZ$0.82 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Financial & insurance services;
- Agricultural support services;
- Rental, hiring & real estate;
- Agriculture;
- Owner-occupied property operation; and
- Basic material wholesaling.

Household income

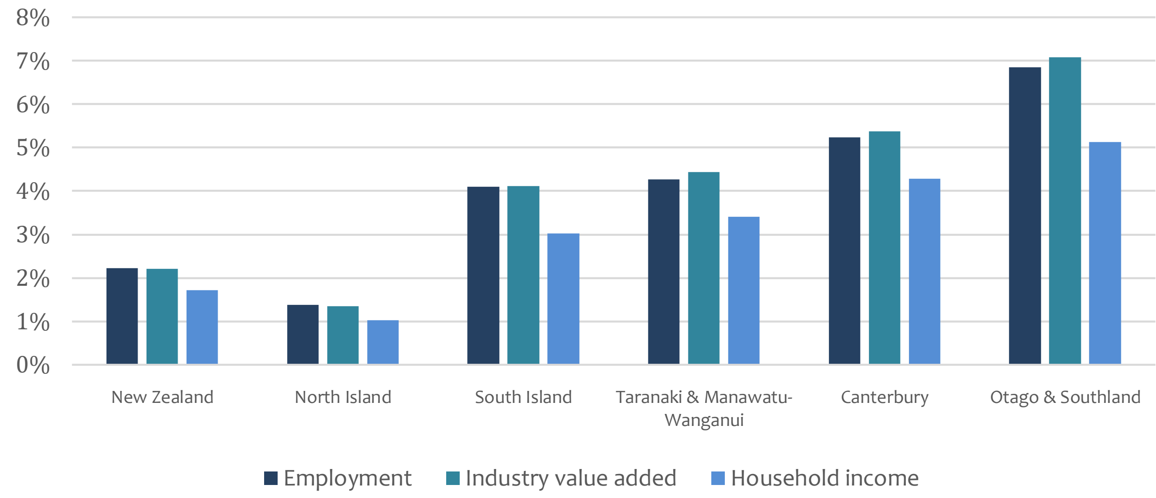
Finally, the livestock production sector is estimated to contribute approximately 5.1 percent of household income in the combined Regional Council areas of Otago and Southland, equating to approximately NZ$0.36 billion in 2017-18. As a result of relatively low compensation of employees in the sector, combined with owners reportedly being remunerated from gross operating surplus, more than 85 percent of the household income impacts are derived from flow-on effects.

4.7 Summary for the livestock production sector

The preceding analysis illustrates that the economic contribution of the livestock production sector, including flow-on impacts, measured in total and contribution to the national and relevant regional economy, under the metrics of employment (FTE), industry value added and household income varies significantly between the geographical regions examined. The sector is, however, a significant contributor to the economy, particularly at the regional level.

At the national level, the sector contributes approximately 2.2 percent of FTE employment and industry value added when flow-on effects are taken into account, a proportion which is significant. However, the magnitude of the contribution is more pronounced at the regional level as illustrated below.

Figure 4.1: Contribution of the livestock production sector (including flow-on effects) to the relevant economy, 2017-18



The overall contribution of the red meat industry, defined as livestock production combined with the red meat processing sector, is assessed in Section 6 of this report.

5.0 Economic contribution of the red meat processing and exporting sector

The economic contribution of the red meat processing and exporting sector reflects expenditure made by processing facilities in the processing of cattle (including beef and dairy cattle including bobby calves), sheep and, to a lesser extent, deer, which form only a very small proportion of the red meat processing and exporting sector. It should be noted that the processing of deer is only included for New Zealand as a whole.

A key point to note is that the processing data includes that associated with adult beef and dairy cattle. The latter, whilst accounting for approximately 42 percent of all adult cattle processed[3] as reported by SNZ, in 2017-18, would generally not be included in the B+LNZ Sheep and Beef Farm Survey, particularly in relation to dairy cows. A proportion of expenditure on cattle by the red meat processing sector has therefore been assumed to be directed to the dairy farming sector (a sub-sector of *Agriculture*

[3] http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=51cbd441-cb4e-444c-9267-1db497bc4a72

in this analysis). Whilst this varies by geographical region, it approximates 35 percent for New Zealand as a whole, in line with B+LNZ estimates[4].

5.1 Economic contribution – New Zealand

The economic contribution of the red meat processing and exporting sector on New Zealand as a whole is summarised in Table 5.1.

Table 5.1: Economic contribution of red meat processing and exporting, New Zealand, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	19,662	1,645	1,131
Flow-on contribution	66,673	9,457	3,193
Total contribution	86,335	11,103	4,324
As % of New Zealand	4.4%	3.9%	3.7%

Source: SGH estimates using aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat processing and exporting sector supports approximately 4.4 percent of the FTE workforce in New Zealand, with approximately 19,660 FTEs being employed directly and almost 66,700 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Beef & sheep farming (13,810 FTEs or 86.1% of total employed in the sector);
- Agriculture (balance excluding beef & sheep farming) (10,870 FTEs or 13.4% of total employed in the sector);
- Agricultural support services (5,040 FTEs or 19.9% of total employed in the sector);
- Financial & insurance services (2,830 FTEs or 4.3% of total employed in the sector);
- Public administration & defence (2,490 FTEs or 2.2% of total employed in the sector); and
- Road transport (2,400 FTEs or 6.1% of total employed in the sector).

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

4 B+LNZ have noted that their estimates differ from those published by SNZ (which in turn are derived from Ministry of Primary Industries and NAIT data). B+LNZ estimate that approximately 35 percent of cattle slaughter is derived from dairy farms.

The red meat processing and exporting sector is also estimated to contribute approximately 3.9 percent of the industry value added in New Zealand when flow-on effects are taken into account. This equates to approximately NZ$1.6 billion in direct effects and NZ$9.5 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Beef & sheep farming;
- Agriculture (balance excluding beef & sheep farming);
- Financial & insurance services;
- Owner-occupied property operation;
- Rental, hiring & real estate; and
- Agricultural support services.

Household income

Finally, the red meat processing and exporting sector is estimated to contribute approximately 3.7 percent of household income in New Zealand, equating to approximately NZ$4.3 billion in 2017-18. As a result of relatively low average compensation of employees in the sector almost 74 percent of the household income impacts are derived from flow-on effects.

5.2 Economic contribution – North Island

The economic contribution of the red meat processing and exporting sector on the North Island is summarised in Table 5.2. It should be noted that the direct contribution totals for the North and South Islands combined are marginally lower than for New Zealand as a whole, as deer processing has been excluded from each island's contributions.

Table 5.2: Economic contribution of red meat processing, North Island, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	11,267	883	595
Flow-on contribution	34,902	5,013	1,686
Total contribution	46,169	5,896	2,281
As % of North Island	3.1%	2.7%	2.5%

Source: SGH estimates using aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat processing and exporting sector supports approximately 3.1 percent of the FTE workforce in the North Island, with approximately 11,300 FTEs being employed directly and a further almost 35,000 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Beef & sheep farming (7,470 FTEs or 89.7% of total employment in the sector);
- Agriculture (balance excluding beef & sheep farming) (6,290 FTEs or 12.1% of total employment in the sector);
- Agricultural support services (2,320 FTEs or 14.0% of total employment in the sector);
- Financial & insurance services (1,450 FTEs or 2.6% of total employment in the sector);
- Road transport (1,350 FTEs or 4.8% of total employment in the sector); and
- Public administration & defence (1,210 FTEs or 1.3% of total employment in the sector).

Industry value added

The red meat processing and exporting sector is also estimated to contribute approximately 2.7 percent of the North Island's industry value added when flow-on effects are taken into account. This equates to approximately NZ$0.9 billion in direct effects and NZ$5.0 billion in flow-on impacts. The top six sectors benefitting from flow on industry value added impacts are, in descending order of significance:

- Beef & sheep farming;
- Agriculture (balance excluding beef & sheep farming);
- Financial & insurance services;
- Owner-occupied property operation;
- Rental, hiring & real estate; and
- Agricultural support services.

Household income

Finally, the red meat processing sector is estimated to contribute approximately 2.5 percent of household income in the North Island, equating to almost NZ$2.3 billion in 2017-18. As a result of relatively low compensation of employees in the sector almost 74 percent of the household income impacts are derived from flow-on effects.

5.3 Economic contribution – South Island

The economic contribution of the red meat processing sector on the South Island is summarised in Table 5.3. It should be noted that the direct contribution totals for the North and South Islands combined are marginally lower than for New Zealand as a whole, as deer processing has been excluded from each island's contributions.

Table 5.3: Economic impact of red meat processing, South Island, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contributions	8,168	725	510
Flow-on contributions	25,396	3,082	1,079
Total contributions	33,564	3,807	1,589
As % of South Island	6.9%	6.0%	5.8%

Source: SGH estimates using aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat processing and exporting sector supports approximately 6.9 percent of the FTE workforce in the South Island, with approximately 8,200 FTEs being employed directly and a further 25,400 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Beef & sheep farming (5,530 FTEs or 71.7% of total employment in the sector);
- Agriculture (balance excluding beef & sheep farming) (5,140 FTEs or 17.9% of total employment in the sector);
- Agricultural support services (2,180 FTEs or 24.7% of total employment in the sector);
- Financial & insurance services (970 FTEs or 9.1% of total employment in the sector);
- Road transport (850 FTEs or 7.9% of total employment in the sector); and
- Health care & social assistance (690 FTEs or 1.5% of total employment in the sector).

Industry value added

The red meat processing and exporting sector is also estimated to contribute approximately 6.0 percent of the South Island's industry value added when flow-on effects are taken into account. This equates to approximately NZ$0.7 billion in direct effects and NZ$3.1 billion in flow-on impacts. The top six sectors benefitting from flow on industry value added impacts are, in descending order of significance:

- Beef & sheep farming;
- Agriculture (balance excluding beef & sheep farming);
- Financial & insurance services;
- Rental, hiring & real estate;
- Owner-occupied property operation; and
- Agricultural support services.

Household income

Finally, the red meat processing and exporting sector is estimated to contribute approximately 5.8 percent of household income in the South Island, equating to almost NZ$1.6 billion in 2017-18. As a result of relatively low compensation of employees in the sector almost 68 percent of the household income impacts are derived from flow-on effects.

5.4 Economic contribution – Taranaki & Manawatu-Wanganui combined

The economic contribution of the red meat processing sector on the combined Regional Council areas of Taranaki and Manawatu-Wanganui is summarised in Table 5.4. It should be noted that processors within the overall region were asked to provide data relating to the proportion of total expenditure by category that was made within and outside the region. Expenditure made outside the region is treated as an import in the IO analysis and accordingly, it should be recognised that red meat processing facilities in the Taranaki and Manawatu-Wanganui region contribute to the economy of other regions through e.g. processing livestock sourced externally.

Table 5.4: Economic contribution of red meat processing, Taranaki & Manawatu-Wanganui combined, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	3,216	262	188
Flow-on contribution	8,139	1,231	370
Total contribution	11,355	1,493	558
As % of Taranaki & Manawatu-Wanganui	8.2%	7.9%	7.6%

Source: SGH estimates using aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat processing sector supports approximately 8.2 percent of the FTE workforce in the combined Regional Council areas of Taranaki and Manawatu-Wanganui, with approximately 3,200 FTEs being employed directly and a further more than 8,100 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (balance excluding beef & sheep farming) (1,350 FTEs or 4.1% of total employment in the sector);
- Beef & sheep farming (1,240 FTEs or 63.4% of total employment in the sector);
- Agricultural support services (420 FTEs or 18.3% of total employment in the sector);
- Health care & social assistance (390 FTEs or 2.6% of total employment in the sector);
- Road transport (350 FTEs or 0.9% of total employment in the sector); and
- Other retailing (300 FTEs or 4.9% of total employment in the sector).

Industry value added

The red meat processing sector is also estimated to contribute approximately 7.9 percent of the industry value added in the combined Regional Council areas of Taranaki and Manawatu-Wanganui when flow-on effects are taken into account. This equates to approximately NZ$0.26 billion in direct effects and NZ$1.2 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture (balance excluding beef & sheep farming);
- Beef & sheep farming;
- Owner-occupied property operation;
- Rental, hiring & real estate;
- Financial & insurance services; and
- Agricultural support services.

Household income

Finally, the red meat production and exporting sector is estimated to contribute approximately 7.6 percent of household income in the combined Regional Council areas of Taranaki and Manawatu-Wanganui, equating to approximately NZ$0.56 billion in 2017-18. As a result of relatively low compensation of employees in the sector, approximately two-thirds of the household income impacts are derived from flow-on effects.

5.5 Economic contribution – Canterbury

The economic contribution of the red meat processing and exporting sector on the Canterbury Regional Council area is summarised in Table 5.5. It should be noted that processors within the overall region were asked to provide data relating to the proportion of total expenditure by category that was made within and outside the region. Expenditure made outside the region is treated as an import in the IO analysis and accordingly, it should be recognised that red meat processing facilities in the Canterbury region contribute to the economy of other regions through e.g. processing livestock sourced externally.

Table 5.5: Economic contribution of red meat processing, Canterbury, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	3,237	261	194
Flow-on contribution	7,501	1,055	347
Total contribution	10,738	1,315	541
As % of Canterbury	4.0%	3.7%	3.8%

Source: SGH estimates using aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat processing and exporting sector supports approximately 4.0 percent of the FTE workforce in the Canterbury Regional Council area, with approximately 3,200 FTEs being employed directly and a further 7,500 FTE jobs being underpinned by the sector as a result of flow-on impacts.

The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Beef & sheep farming (1,520 FTEs or 39.4% of total employment in the sector);

- Agriculture (balance excluding beef & sheep farming) (760 FTEs or 7.4% of total employment in the sector);
- Agricultural support services (580 FTEs or 19.6% of total employment in the sector);
- Financial & insurance services (390 FTEs or 6.2% of total employment in the sector);
- Health care & social assistance (320 FTEs or 1.2% of total employment in the sector); and
- Public administration & defence (260 FTEs or 2.3% of total employment in the sector).

Industry value added

The red meat processing and exporting sector is also estimated to contribute approximately 3.7 percent of the industry value added in the Canterbury Regional Council area when flow-on effects are taken into account. This equates to approximately NZ$0.26 billion in direct effects and NZ$1.1 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Beef & sheep farming;
- Financial & insurance services;
- Owner-occupied property operation;
- Rental, hiring & real estate;
- Agriculture (balance excluding beef & sheep farming); and
- Agricultural support services.

Household income

Finally, the red meat production and exporting sector is estimated to contribute approximately 3.8 percent of household income in the Canterbury Regional Council area, equating to approximately NZ$0.54 billion in 2017-18. As a result of relatively low compensation of employees in the sector, approximately 64 percent of the household income impacts are derived from flow-on effects.

5.6 Economic contribution – Otago & Southland combined

The economic contribution of the red meat processing and exporting sector on the combined Regional Council areas of Otago and Southland is summarised in Table 5.6. It should be noted that processors within the overall region were asked to provide data relating to the proportion of total expenditure by category that was made within and outside the region. Expenditure made outside the region is treated as an import in the IO analysis and accordingly, it should be recognised that red meat processing facilities in the Otago and Southland regions contribute to the economy of other regions.

Table 5.6: Economic contribution of red meat processing, Otago & Southland combined, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	4,475	363	274
Flow-on contribution	10,180	1,390	414
Total contribution	14,655	1,752	687
As % of Otago & Southland	10.1%	9.5%	9.8%

Source: SGH estimates using aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat processing and exporting sector supports approximately 10.1 percent of the FTE workforce in the combined Regional Council areas of Otago and Southland, with approximately 4,500 FTEs being employed directly and a further 10,200 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Beef & sheep farming (2,160 FTEs or 67.6% of total employment in the sector);
- Agriculture (balance excluding beef & sheep farming) (1,250 FTEs or 10.8% of total employment in the sector);
- Agricultural support services (1,050 FTEs or 7.1% of total employment in the sector);
- Financial & insurance services (430 FTEs or 13.6% of total employment in the sector);
- Health care & social assistance (400 FTEs or 3.0% of total employment in the sector); and
- Other retailing (340 FTEs or 5.1% of total employment in the sector).

Industry value added

The red meat processing and exporting sector is also estimated to contribute approximately 9.5 percent of the industry value added in the combined Regional Council areas of Otago and Southland when flow-on effects are taken into account. This equates to approximately NZ$0.36 billion in direct effects and NZ$1.4 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Beef & sheep farming;
- Agriculture (balance excluding beef & sheep farming);
- Financial & insurance services;
- Owner-occupied property operation;
- Rental, hiring & real estate; and
- Agricultural support services.

Household income

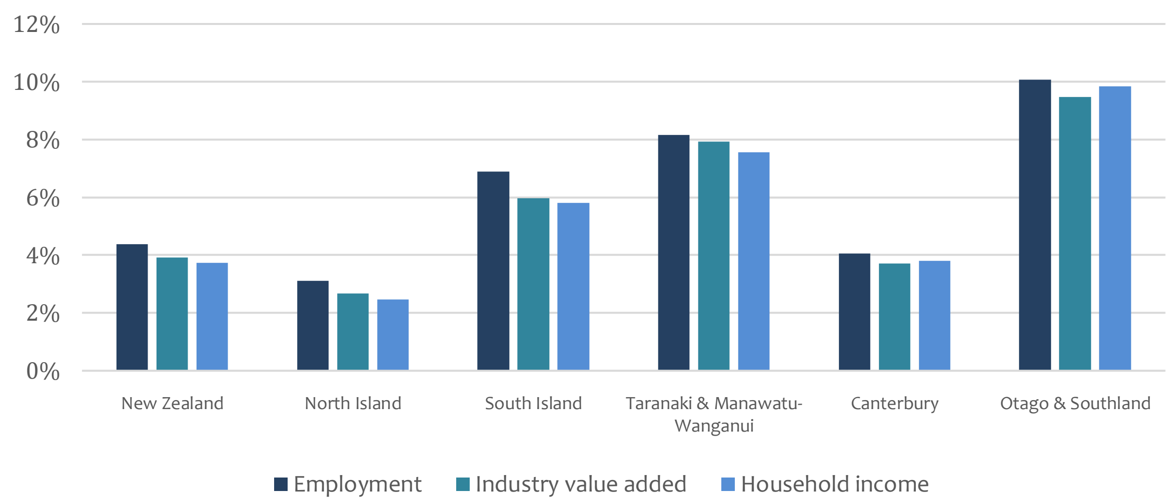
Finally, the red meat production sector is estimated to contribute approximately 9.8 percent of household income in the combined Regional Council areas of Otago and Southland, equating to approximately NZ$0.69 billion in 2017-18. As a result of relatively low compensation of employees in the sector, approximately 60 percent of the household income impacts are derived from flow-on effects.

5.7 Summary for the red meat processing and exporting sector

The preceding analysis illustrates that the economic contribution of the red meat processing sector, including flow-on impacts, measured in total and contribution to the national and relevant regional economy, under the metrics of employment (FTE), industry value added and household income varies significantly between the geographical regions examined. The sector is, however, a significant contributor to the economy, particularly at the regional level.

At the national level, the sector contributes approximately 4.4 percent of FTE employment and 3.9 percent of industry value added when flow-on effects are taken into account, a proportion which is significant. However, the magnitude of the contribution is more pronounced at the regional level as illustrated below.

Figure 5.1: Contribution of the red meat processing sector (including flow-on effects) to the relevant economy, 2017-18



6.0 Economic contribution of the red meat industry in total

This section examines the economic contribution of the red meat industry in total i.e. livestock production and red meat processing and exporting combined, at each of the geographic areas already outlined. It is important to note that this contribution cannot be measured by simply aggregating the results for each of the livestock production and red meat processing sectors as this would result in significant over-estimation through double-counting, particularly related to livestock transactions. In addition, it would also reflect double-counting in flow-on impacts e.g. expenditure by the red meat processing and exporting sector on livestock has flow-on effects in the livestock production sector which have already been included, either directly or indirectly, in that sector.

In order to overcome these issues, estimating the contribution of the red meat industry in total has been undertaken by aggregating the two sectors in the relevant IO tables. This effectively leaves the initial contributions of both sectors intact but reduces the combined flow-on effects.

It should again be noted that the economic contribution of the red meat industry in total includes the processing of dairy cattle and bobby calves, a proportion of which are not included in the B+LNZ Sheep and Beef Farm Survey. Accordingly, the economic contribution of the red meat industry in total is larger than it would be if only beef cattle were included.

6.1 Economic contribution – New Zealand

The economic contribution of the red meat industry (i.e. livestock production and red meat processing and exporting in aggregate) on New Zealand as a whole is summarised in Table 6.1.

Table 6.1: Economic contribution of the red meat industry, New Zealand, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	35,702	3,775	1,477
Flow-on contribution	56,719	8,197	3,124
Total contribution	92,421	11,973	4,601
As % of New Zealand	4.7%	4.2%	4.0%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat industry supports approximately 4.7 percent of the FTE workforce in New Zealand, with approximately 35,700 FTEs being employed directly and more than 56,700 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (11,040 FTEs or 11.4% of total employment in the sector);
- Agricultural support services (5,790 FTEs or 22.8% of total employment in the sector);
- Financial & insurance services (3,180 FTEs or 4.8% of total employment in the sector);

- Public administration & defence (2,790 FTEs or 2.5% of total employment in the sector);
- Road transport (2,510 FTEs or 6.4% of total employment in the sector); and
- Health care & social assistance (2,330 FTEs or 1.3% of total employment in the sector.

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

The red meat industry is also estimated to contribute approximately 4.2 percent of the industry value added in New Zealand when flow-on effects are taken into account. This equates to approximately NZ$3.8 billion in direct effects and NZ$8.2 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture;
- Financial & insurance services;
- Owner-occupied property operation;
- Rental, hiring & real estate;
- Agricultural support services; and
- Road transport.

Household income

Finally, the red meat industry is estimated to contribute approximately 4.0 percent of household income in New Zealand, equating to approximately NZ$4.6 billion in 2017-18. As a result of relatively low average compensation of employees in the sectors almost 68 percent of the household income impacts are derived from flow-on effects.

6.2 Economic contribution – North Island

The economic contribution of the red meat industry (i.e. livestock production and red meat processing and exporting in aggregate) on the North Island is summarised in Table 6.2.

Table 6.2: Economic contribution of the red meat industry, North Island, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	19,597	1,986	785
Flow-on contribution	28,678	4,214	1,594
Total contribution	48,275	6,200	2,379
As % of North Island	3.2%	2.8%	2.6%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat industry supports approximately 3.2 percent of the FTE workforce in the North Island, with approximately 19,600 FTEs being employed directly and almost 28,700 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (6,330 FTEs or 10.5% of total employment in the sector);
- Agricultural support services (2,560 FTEs or 15.4% of total employment in the sector);
- Financial & insurance services (1,570 FTEs or 2.8% of total employment in the sector);
- Road transport (1,390 FTEs or 4.9% of total employment in the sector);
- Public administration & defence (1,300 FTEs or 1.4% of total employment in the sector); and
- Health care & social assistance (1,120 FTEs or 0.8% of total employment in the sector).

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

The red meat industry is also estimated to contribute approximately 2.8 percent of the industry value added in the North Island when flow-on effects are taken into account. This equates to approximately NZ$2.0 billion in direct effects and NZ$4.2 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture;
- Financial & insurance services;
- Owner-occupied property operation;
- Rental, hiring & real estate;
- Agricultural support services; and
- Road transport.

Household income

Finally, the red meat industry is estimated to contribute approximately 2.6 percent of household income in the North Island, equating to approximately NZ$2.4 billion in 2017-18. As a result of relatively low average compensation of employees in the sectors almost 67 percent of the household income impacts are derived from flow-on effects.

6.3 Economic contribution – South Island

The economic contribution of the red meat industry (i.e. livestock production and red meat processing in aggregate) on the South Island is summarised in Table 6.3.

Table 6.3: Economic contribution of the red meat industry, South Island, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	15,878	1,744	664
Flow-on contribution	23,342	2,804	1,159
Total contribution	39,219	4,548	1,823
As % of South Island	8.0%	7.1%	6.7%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat industry supports approximately 8.0 percent of the FTE workforce in the South Island, with approximately 15,900 FTEs being employed directly and more than 23,300 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (5,340 FTEs or 14.7% of total employment in the sector);
- Agricultural support services (2,980 FTEs or 33.8% of total employment in the sector);
- Financial & insurance services (1,280 FTEs or 12.1% of total employment in the sector);
- Road transport (960 FTEs or 8.8% of total employment in the sector);
- Public administration & defence (890 FTEs or 4.4% of total employment in the sector); and
- Health care & social assistance (790 FTEs or 1.7% of total employment in the sector).

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

The red meat industry is also estimated to contribute approximately 7.1 percent of the industry value added in the South Island when flow-on effects are taken into account. This equates to approximately NZ$1.7 billion in direct effects and NZ$2.8 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture;
- Financial & insurance services;
- Rental, hiring & real estate;

- Owner-occupied property operation;
- Agricultural support services; and
- Road transport.

Household income

Finally, the red meat industry is estimated to contribute approximately 6.7 percent of household income in the South Island, equating to approximately NZ$1.8 billion in 2017-18. As a result of relatively low average compensation of employees in the sectors almost 64 percent of the household income impacts are derived from flow-on effects.

6.4 Economic contribution – Taranaki & Manawatu-Wanganui combined

The economic contribution of the red meat industry (i.e. livestock production and red meat processing in aggregate) on the combined Regional Council areas of Taranaki and Manawatu-Wanganui is summarised in Table 6.4.

Table 6.4: Economic contribution of the red meat industry, Taranaki & Manawatu-Wanganui, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	5,176	498	234
Flow-on contribution	8,340	1,300	416
Total contribution	13,516	1,798	650
As % of Taranaki & Manawatu-Wanganui	9.7%	9.5%	8.8%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat industry supports approximately 9.7 percent of the FTE workforce in the combined Regional Council areas of Taranaki and Manawatu-Wanganui, with approximately 5,200 FTEs being employed directly and more than 8,300 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (1,540 FTEs or 12.3% of total employment in the sector);
- Agricultural support services (590 FTEs or 26.1 % of total employment in the sector);
- Health care & social assistance (450 FTEs or 3.1% of total employment in the sector);

- Financial & insurance services (410 FTEs or 14.7% of total employment in the sector);
- Road transport (390 FTEs or 11.1% of total employment in the sector); and
- Other retailing (350 FTEs or 5.8% of total employment in the sector).

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

The red meat industry is also estimated to contribute approximately 9.5 percent of the industry value added in the combined Regional Council areas of Taranaki and Manawatu-Wanganui when flow-on effects are taken into account. This equates to approximately NZ$0.5 billion in direct effects and NZ$1.3 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture;
- Owner-occupied property operation;
- Financial & insurance services;
- Rental, hiring & real estate;
- Agricultural support services; and
- Electricity generation & supply.

Household income

Finally, the red meat industry is estimated to contribute approximately 8.8 percent of household income in the combined Regional Council areas of Taranaki and Manawatu-Wanganui, equating to approximately NZ$0.65 billion in 2017-18. As a result of relatively low average compensation of employees in the sectors almost 64 percent of the household income impacts are derived from flow-on effects.

6.5 Economic contribution – Canterbury

The economic contribution of the red meat industry (i.e. livestock production and red meat processing in aggregate) on the Canterbury Regional Council area is summarised in Table 6.5.

Table 6.5: Economic contribution of the red meat industry, Canterbury, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	7,097	830	302
Flow-on contribution	12,062	1,639	608
Total contribution	19,159	2,469	911
As % of Canterbury	7.2%	7.0%	6.4%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat industry supports approximately 7.2 percent of the FTE workforce in the Canterbury Regional Council area, with approximately 7,000 FTEs being employed directly and more than 12,000 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agriculture (1,750 FTEs or 12.4% of total employment in the sector);
- Agricultural support services (1,450 FTEs or 49.4% of total employment in the sector);
- Financial & insurance services (870 FTEs or 13.8% of total employment in the sector);
- Public administration & defence (600 FTEs or 5.2% of total employment in the sector);
- Basic material wholesaling (530 FTEs or 16.2% of total employment in the sector); and
- Health care & social assistance (530 FTEs or 2.1% of total employment in the sector).

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

The red meat industry is also estimated to contribute approximately 7.0 percent of the industry value added in the Canterbury Regional Council area when flow-on effects are taken into account. This equates to approximately NZ$0.8 billion in direct effects and NZ$1.6 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Financial & insurance services;
- Rental, hiring & real estate;
- Agriculture;
- Owner-occupied property operation;
- Agricultural support services; and
- Basic material wholesaling.

Household income

Finally, the red meat industry is estimated to contribute approximately 6.4 percent of household income in the Canterbury Regional Council area, equating to approximately NZ$0.9 billion in 2017-18. As a result of relatively low average compensation of employees in the sectors almost 67 percent of the household income impacts are derived from flow-on effects.

6.6 Economic contribution – Otago & Southland combined

The economic contribution of the red meat industry (i.e. livestock production and red meat processing in aggregate) on the combined Regional Council areas of Otago and Southland is summarised in Table 6.6.

Table 6.5: Economic contribution of the red meat industry, Otago & Southland, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	7,675	847	327
Flow-on contribution	10,103	1,330	477
Total contribution	17,777	2,176	804
As % of Otago & Southland	12.2%	11.8%	11.5%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

The individual metrics are examined below.

Employment

Overall, it is estimated that the red meat industry supports approximately 12.2 percent of the FTE workforce in the combined Regional Council areas of Otago and Southland, with approximately 7,700 FTEs being employed directly and more than 10,000 FTE jobs being underpinned by the sector as a result of flow-on impacts. The top six sectors benefitting from flow-on employment impacts are, in descending order of significance:

- Agricultural support services (1,520 FTEs or 40.9% of total employment in the sector);
- Agriculture (1,440 FTEs or 9.8% of total employment in the sector);
- Financial & insurance services (580 FTEs or 18.6% of total employment in the sector);
- Health care & social assistance (460 FTEs or 3.5% of total employment in the sector);
- Public administration & defence (430 FTEs or 7.1% of total employment in the sector); and
- Other retailing (400 FTEs and 6.0% of total employment in the sector).

It should be noted that the flow-on impacts in *Agriculture* predominantly flow to the *Dairy cattle farming* sector.

Industry value added

The red meat industry is also estimated to contribute approximately 11.8 percent of the industry value added in the combined Regional Council areas of Otago and Southland when flow-on effects are taken into account. This equates to approximately NZ$0.85 billion in direct effects and NZ$1.3 billion in flow-on impacts. The top six sectors benefitting from flow-on industry value added impacts are, in descending order of significance:

- Agriculture;
- Financial & insurance services;
- Rental, hiring & real estate;
- Owner-occupied property operation;
- Agricultural support services; and
- Electricity generation & supply.

Household income

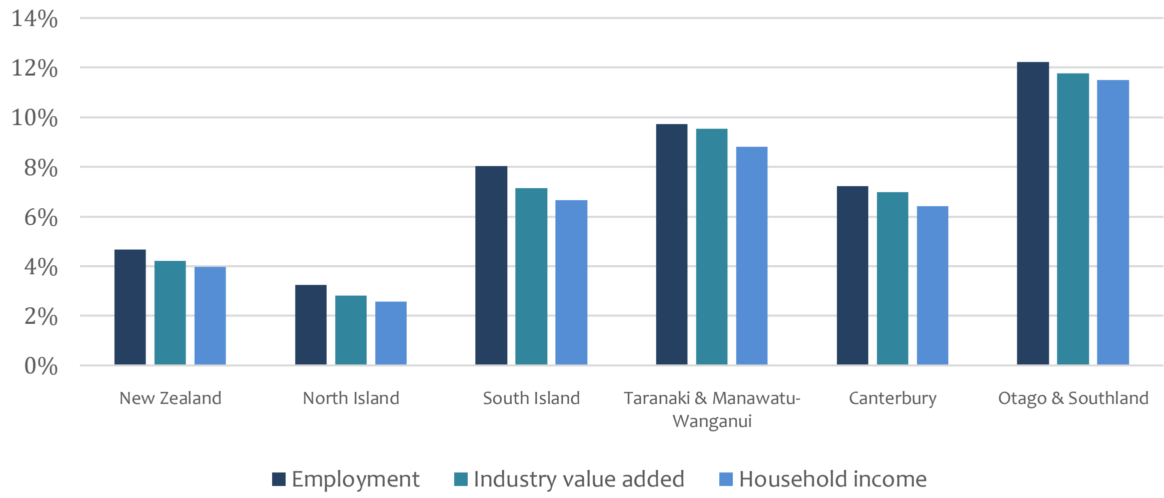
Finally, the red meat industry is estimated to contribute approximately 11.5 percent of household income in the combined Regional Council areas of Otago and Southland, equating to approximately NZ$0.8 billion in 2017-18. As a result of relatively low average compensation of employees in the sectors almost 59 percent of the household income impacts are derived from flow-on effects.

6.8 Summary for the red meat industry in total

The preceding analysis illustrates that the economic contribution of the red meat industry in total, including flow-on impacts, measured in total and contribution to the national and relevant regional economy, under the metrics of employment (FTE), industry value added and household income varies significantly between the geographical regions examined. The sector is, however, a significant contributor to the economy, particularly at the regional level.

At the national level, the sector contributes approximately 4.7 percent of FTE employment and 4.2 percent of industry value added when flow-on effects are taken into account, a proportion which is significant. However, the magnitude of the contribution is more pronounced at the regional level as illustrated below.

Figure 6.1: Contribution of the red meat industry in total (including flow-on effects) to the relevant economy, 2017-18



7.0 Conclusions

The red meat industry and its individual components (livestock production and red meat processing and exporting) make a significant contribution to the New Zealand economy and, when examined at a regional level, can contribute more than 10 percent of the various measures when flow-on effects are included.

The red meat industry makes a significant contribution to the national economy in terms of employment, household income and industry value added, as summarised in Table 7.1.

When flow-on effects are taken into account, the red meat industry contributes 4.2 percent of national industry value added, 4.0 percent of household income and 4.7 percent of full-time equivalent employment.

Table 7.1: Economic contribution of the red meat industry, New Zealand, 2017-18

	Employment	Industry value added	Household income
	FTE	NZ$ million	NZ$ million
Direct contribution	35,702	3,775	1,477
Flow-on contribution	56,719	8,197	3,124
Total contribution	92,421	11,973	4,601
As % of New Zealand	4.7%	4.2%	4.0%

Source: SGH estimates using B+LNZ data, aggregated private data from processors and SNZ data

In order to provide overall context for this analysis, Table 7.2 provides a summary distribution of industry value added by industry for the year ending March 2018.

Table 7.2: Contribution to Gross Industry Value Added, New Zealand, 2017-18

	2018	
	$ million	% of total
Agriculture	12,431	4.7%
Forestry and logging	1,910	0.7%
Fishing, aquaculture and agriculture, forestry and fishing support services	2,470	0.9%
Mining	2,883	1.1%
Food, beverage and tobacco product manufacturing	10,602	4.0%
Textile, leather, clothing and footwear manufacturing	674	0.3%
Wood and paper products manufacturing	2,288	0.9%
Printing	681	0.3%
Petroleum, chemical, polymer and rubber product manufacturing	5,452	2.1%
Non-metallic mineral product manufacturing	1,210	0.5%
Metal product manufacturing	3,044	1.2%
Transport equipment, machinery and equipment manufacturing	4,897	1.9%
Furniture and other manufacturing	767	0.3%
Electricity, gas, water and waste services	8,026	3.0%
Construction	18,540	7.0%
Wholesale trade	14,202	5.4%
Retail trade	12,998	4.9%
Accommodation and food services	6,360	2.4%

Transport, postal, and warehousing	13,012	4.9%
Information media and telecommunications	6,777	2.6%
Financial and insurance services	16,973	6.4%
Rental, hiring, and real estate services	21,171	8.0%
Owner-occupied property operation	18,321	6.9%
Professional, scientific, and technical services	23,152	8.8%
Administrative and support services	5,681	2.1%
Local government administration	1,374	0.5%
Central government administration, defence, and public safety	10,157	3.8%
Education and training	12,258	4.6%
Health care and social assistance	16,843	6.4%
Arts and recreation services	3,853	1.5%
Other services	5,314	2.0%
Total all industries	264,323	100.0%
Primary industry sector	19,694	7.5%
Secondary industry sector	29,615	11.2%
Tertiary industry sector	215,012	81.3%

Source: SNZ data

It should be noted that in most developed countries the tertiary or service sector contributes around 80 per cent of national industry value added, and New Zealand is no exception. The preceding table provides a summary distribution of industry value added by industry for the year ending March 2018, and indicates that the tertiary sector contributes around 81 per cent and primary and secondary sectors contribute around 19 per cent of gross industry value added in New Zealand.

In order to prevent double counting, it is best to compare direct contributions to national industry value added without flow-on effects. On that basis, the red meat sector contributes directly around 1.4 per cent to national industry value added. This means it contributes fully 7.7 per cent of all national non-tertiary value added.

Moreover, the red meat industry is a major contributor to the Island and regional economies identified in this report, with its contribution reaching more than 11.8 percent of value added and in excess of 12.2 percent of FTE employment in some cases.

The social impacts of the industry will be analysed in a subsequent study.

The project represents a significant achievement by, and for, the red meat industry. A large number of processors and exporters have provided up-to-date financial data to enable establishment of a comprehensive data set on industry costs which have enabled the industry to determine the economic contribution of the red meat processing sector regionally and nationally. Similarly, the Sheep and Beef Farm Surveys conducted by B+LNZ have permitted analysis of the economic contribution of the livestock production sector

There are also substantial secondary benefits for the industry generated by this research. The model can be used for analysing the contribution on the industry, and hence on the regional, Island and national economies, of regulatory, technical or other developments which might impact it – e.g. new regulations, innovations or practices that affect the cost structure of the industry.

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Appendix 1 – Input Output Analysis

Input output (IO) analysis is a macroeconomic analysis based on the interdependencies between economic categories, usually defined as industries or sub-industry categories. IO analysis is frequently used for estimating the contributions of sectors (defined as industry sectors, sub-sectors in isolation or in aggregate, or individual enterprises, on an economy) from existing operations (i.e. already part of the economy) or changes to these through either positive or negative economic shocks and analysing the flow-on effects throughout an economy.

The basis of IO analysis involves input output tables which include a series of rows and columns of data that quantify the supply chain for all sectors of an economy, representing inter-industry sales and purchases as well as sales to final demand (household and government final consumption expenditure, capital formation and exports) and expenditure on primary inputs (compensation of employees, gross operating surplus, taxes & subsidies on production & products and imports).

The data in each column corresponds to the level of inputs used in that industry's production function. For example, the column for *Meat and meat product manufacturing* illustrates the financial inputs required to produce meat products (e.g. livestock purchases, utilities usage, transport costs etc). The row for each sector in the matrix indicates the sales from that sector to other sectors (e.g. for *Agriculture*, sales to a range of food and beverage manufacturing sectors, and to the various final demand sectors).

The base table utilised for the analysis is derived from the most recent table published by Statistics New Zealand (SNZ) for New Zealand as a whole for the year end March 2013[5], published in 2016. That table comprises 106 categories which, in turn, are concorded with ANZSIC classifications for 2006[6].

The base table has been updated to 2017-18 using a range of data sources published by Statistics New Zealand including:

- Annual enterprise survey;
- Business demography data;
- Linked employer-employee data (LEED);
- Manufacturing survey;
- National accounts (income and expenditure); and
- National accounts (production and investment).

5 http://archive.stats.govt.nz/browse_for_stats/economic_indicators/NationalAccounts/input-output%20tables-2013.aspx
6 Australian and New Zealand Standard Industrial Classification 2006 - http://aria.stats.govt.nz/aria/?_ga=2.166244606.111743353.1574913770-1230729022.1555024637#ClassificationView:uri=http://stats.govt.nz/cms/ClassificationVersion/CARS5587

Employment numbers

The impact of employment can be measured in a number of ways but all primarily relate to using either:

1. total employment counts in a given time period; or
2. estimating the number of full-time equivalent (FTE) employees.

When conducting economic contribution analysis, the latter is the preferred method because it enables a direct comparison between industry sectors. Total employment counts do not reflect the differences between sectors in which a significant proportion of employment is on a part-time basis (e.g. *Retail trade*, *Accommodation*, *Food services*) and those in which the vast majority of employment is on a full-time basis (e.g. *Electricity, gas, water & waste services*, *Manufacturing*, *Financial & insurance services*). It also does not reflect the fact that, by international standards relating to labour force statistics, a part-time employee may work anywhere between one and 30 hours per week. The time differentiation for casual employment is not internationally recognised as part of the definition of employment when measuring the labour market, rather casual employment is a contractual definition and is classified only as either full-time or part-time.

SNZ publishes only limited data relating to FTE employment by industry sector under the Earnings and Employment Survey[7]. That data only categorises employment in aggregate and for a limited number of ANZSIC sectors (some of which are combined as illustrated below), which do not reflect the disaggregation into 106 categories provided in the national input output (IO) table. As a result, the relative ratio of FTE employment to total employment count would be misleading if the same ratios were applied across all relevant sub-sectors.

Industry sectors in the Earnings and Employment Survey:

- Forestry & mining
- Manufacturing
- Electricity, gas, water & waste services
- Construction
- Wholesale trade
- Retail trade
- Accommodation and food services
- Transport, postal & warehousing
- Information media & telecommunications
- Financial & insurance services
- Rental, hiring & real estate services
- Professional, scientific, technical, administrative & support services

[7] http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=a8d5f939-8d0d-4ebb-9db4-5288f175253c

- Public administration & safety
- Education & training
- Health care & social assistance
- Arts, recreation & other services

Given these differences in the source data, it was necessary to estimate FTE employment numbers for each of the 106 sectors identified in the national IO table. To do this, the following methodology was adopted.

Data from the Earnings and Employment Survey[8] relating to employment by labour force status (working proprietors, full-time and part-time) for each of the above sectors was analysed to determine the overall proportion of employment in full-time and part-time categories and the associated number of part-time employees equating to one full-time employee.

The total number of employees (i.e. both full-time and part-time) for each of the 106 categories in the IO table was derived from data published by SNZ and allocated by category to each of the previously listed sectors utilised in the Earnings and Employment Survey.

It was then assumed that the distribution of full-time and part-time employment within each of the 106 categories would approximate that experienced in Australia where data from the 2016 Census on employment by labour force status is available at the ANZSIC 2006 Level 4 category. Within each IO category, the Australian distribution by full-time or part-time employment was applied to the total New Zealand employment numbers. The resultant output was then readjusted to reflect both total employment numbers by IO category and the distribution of full-time and part-time employment in each of the Earnings and Employment Survey sectors. The number of part-time employees was then adjusted by the previously calculated number of part-time employees equating to one full-time employee.

Overall, the total calculations reflect total employment numbers by IO category published by SNZ as well as the distribution of employment by status in the Earnings and Employment Survey from the same source.

A similar analysis was undertaken for both the North and South Island and the relevant regions but adjusted to allow for the overall distribution of employment by each of the 106 IO categories in each geographical area.

Aggregation of sectors

Whilst the base IO table has 106 sectors, a number of these are of little relevance to either the livestock production or red meat processing components of the red meat

8 http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=a653520e-7568-44c4-a025-7252ec5ce3eb

industry in New Zealand. Accordingly, the national, and subsequent regional tables, were aggregated to reflect a total of 61 sectors which are outlined in Appendix 2 of this report.

After constructing the base tables, a new row and column were inserted to reflect the red meat production or processing sector, utilising the primary data provided by either B+LNZ or processors, scaled up to reflect national or regional totals where applicable. That new sector was then subtracted from the existing *Agriculture* or *Meat and meat product manufacturing* sectors in order to maintain the integrity of the overall table.

The tables are then rebalanced and the various measures of economic activity calculated, namely employment (measured as full-time equivalent (FTE) positions), industry value added (a sub-set and key component of gross national or regional product) and household income.

Regional tables

In creating the various regional tables, including the North and South Island tables, referred to in this report, the results were compared with the estimates of Gross Regional Product published by SNZ[9] to ensure that, for each of the individual regions, the overall tables were compatible with published data.

Regional tables were constructed using Generation of Regional Input Output Tables (GRIT) files incorporated in the IO9 software used for this analysis. The GRIT approach is the most widely used method of constructing input output tables in Australia. It is also commonly employed in Europe and America.

The GRIT technique, developed by Professors West and Jensen of the University of Queensland, uses allocation methods and location quotients as well as primary data where available. That primary data is regarded as being superior to the data generated using statistical ratios alone. The software allows for manual changes to ratios derived from location quotients, impacting calculation of factors such as various primary inputs (e.g. compensation of employees, gross operating surplus and imports), final demand characteristics (e.g. household final consumption expenditure and exports) and output by sector. This allows for a regional table to be created which reflects available regional data rather than simply using the relevant ratios in the national table. The construction of the regional tables utilised in this analysis incorporated a range of regional data available from SNZ. The resultant tables were then compared with the national table as a validity check.

9 http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=8193e739-6851-4971-9784-38fed9943dce

Estimating economic contributions

The economic contribution of each sector was measured in absolute values and as a percentage of the relevant regional economy. The contributions measured incorporate the following:

- Direct contributions resulting from expenditure associated with the operation of the livestock production or red meat processing facility – labour, materials, services;
- Indirect contributions resulting from the suppliers of the facility purchasing goods and services and hiring workers to meet demand – these "2nd round" contributions would not occur but for facility's operations; and
- Induced contributions resulting from the employees of the facilities purchasing goods and services at a household level.

It is important to recognise that in estimating the contribution to the economy of the livestock production sector, the red meat processing sector or both in aggregate, that they are already part of the existing economy. Therefore, the sector being analysed must be subtracted from the overall economy (or its relevant "parent" sector being *Agriculture* in the case of red meat production and *Meat and meat product manufacturing* in the case of red meat processing) prior to calculating its economic contribution to ensure that the integrity of the table (measured as total Gross Domestic (or Regional) Product) is maintained.

This was undertaken separately for each of the livestock production and red meat processing sectors for New Zealand as a whole and each of the regions.

Livestock production

B+LNZ provided farm-level data from its Sheep and Beef Farm Survey, which is of a statistically representative sample of commercial sheep and beef farms in New Zealand. The weighted averages of metrics were scaled up to reflect the population in each geographical area ("region") based on estimates provided by B+LNZ, which are derived from the Agricultural Production Census conducted by SNZ on behalf of Ministry for Primary Industries (MPI).

The expenditure categories used in the B+LNZ Sheep and Beef Farm Survey do not directly align with the categories in the IO table and therefore had to be allocated to individual IO categories. The distribution of the proportion of expenditure for each of these across the relevant IO categories was reviewed in conjunction with representatives from B+LNZ, and was informed by analysis of the B+LNZ Sheep and Beef Farm Survey data. The key proportional estimates by expenditure category are summarised below:

	Input Output Table Category									
Expenditure category in B+LNZ Sheep and Beef Farm Survey	Veterinary & other professional services	Pharma-ceutical mfg	Basic material w'saling	Agricultural support services	Fertiliser & pesticide mfg	Basic chemical product mfg	Agriculture	Repair	Other w'sale	Metal mfg
Livestock							100%			
Animal Health	25%	50%							25%	
Weed & Pest Control				30%		60%	10%			
Shearing Expenses				100%						
Fertiliser				20%	80%					
Lime				70%		30%				
Seeds			90%				10%			
Feed & Grazing							100%			
Cultivation & Sowing				100%						
Cash Crop Expenses			30%	70%						
Repairs & Maintenance			40%	30%				15%	10%	5%

B+LNZ also provided, from the Sheep and Beef Farm Survey, estimates of on-farm employment (measured in total FTE) and associated wages and salaries for each region.

Red meat processing

The aggregated private data provided directly to the Consultants was utilised to estimate a profile of the industry as a whole for each of the following geographical areas utilising published data on slaughter numbers for 2017-18[10]:

- New Zealand - data coverage from the survey was estimated to incorporate the following percentage of slaughter numbers by animal type:
    - Cattle – 59.3 percent
    - Calves – 65.1 percent
    - Sheep – 67.5 percent
    - Lambs – 66.9 percent
    - Deer – 81.9 percent
- North Island - data coverage from the survey was estimated to incorporate the following percentage of slaughter numbers by animal type:
    - Cattle – 46.7 percent
    - Calves – 49.0 percent
    - Sheep – 54.5 percent
    - Lambs – 47.4 percent
- South Island - data coverage from the survey was estimated to incorporate the following percentage of slaughter numbers by animal type:
    - Cattle – 86.4 percent
    - Calves – 90.2 percent

[10] http://archive.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=13af6c9b-12b7-4ad3-afaf-c339634ea8ea

  - Sheep – 80.4 percent
  - Lambs – 86.4 percent
- Taranaki and Manawatu-Wanganui - data coverage from the survey was estimated to incorporate the following percentage of slaughter numbers by animal type:
  - Cattle – 70.7 percent
  - Calves – 80.8 percent
  - Sheep – 66.9 percent
  - Lambs – 62.6 percent
- Canterbury - data coverage from the survey was estimated to incorporate the following percentage of slaughter numbers by animal type:
  - Cattle – 71.0 percent
  - Calves – 100.0 percent
  - Sheep – 51.9 percent
  - Lambs – 61.1 percent
- Otago and Southland - data coverage from the survey was estimated to incorporate the following percentage of slaughter numbers by animal type:
  - Cattle – 94.1 percent
  - Calves – 81.8 percent
  - Sheep – 76.3 percent
  - Lambs – 82.2 percent

In each case, the data provided by those processing facilities supplying information was scaled up, by animal type, to reflect the relevant geographical area in total, based on slaughter numbers available from SNZ.

Appendix 2 – Concordance of aggregated sectors in the input output tables

106 IO categories	61 IO categories
Horticulture and fruit growing	Agriculture
Sheep, beef cattle, and grain farming	Agriculture
Dairy cattle farming	Agriculture
Poultry, deer, and other livestock farming	Agriculture
Forestry and logging	Forestry and logging
Fishing and aquaculture	Fishing and aquaculture
Agriculture, forestry, and fishing support services	Agricultural support services
Coal mining	Mining
Oil and gas extraction	Mining
Metal ore and non-metallic mineral mining and quarrying	Mining
Exploration and other mining support services	Mining
Meat and meat product manufacturing	Meat and meat product manufacturing
Seafood processing	Seafood processing
Dairy product manufacturing	Dairy product manufacturing
Fruit, oil, cereal, and other food product manufacturing	Fruit, oil, cereal, and other food product manufacturing
Beverage and tobacco product manufacturing	Beverage and tobacco product manufacturing
Textile and leather manufacturing	Textile manufacturing
Clothing, knitted products, and footwear manufacturing	Textile manufacturing
Wood product manufacturing	Wood product manufacturing
Pulp, paper, and converted paper product manufacturing	Pulp, paper, and converted paper product manufacturing
Printing	Printing
Petroleum and coal product manufacturing	Basic chemical manufacturing
Basic chemical and basic polymer manufacturing	Basic chemical manufacturing
Fertiliser and pesticide manufacturing	Fertiliser and pesticide manufacturing
Pharmaceutical, cleaning, and other chemical manufacturing	Pharmaceutical, cleaning, and other chemical manufacturing
Polymer product and rubber product manufacturing	Polymer product and rubber product manufacturing
Non-metallic mineral product manufacturing	Non-metallic mineral product manufacturing
Primary metal and metal product manufacturing	Metal and metal product manufacturing
Fabricated metal product manufacturing	Metal and metal product manufacturing
Transport equipment manufacturing	Machinery and equipment manufacturing
Electronic and electrical equipment manufacturing	Machinery and equipment manufacturing
Machinery manufacturing	Machinery and equipment manufacturing
Furniture manufacturing	Other manufacturing
Other manufacturing	Other manufacturing
Electricity generation and on-selling	Electricity supply
Electricity transmission and distribution	Electricity supply
Gas supply	Gas supply
Water supply	Water supply
Sewerage and drainage services	Sewerage and drainage services
Waste collection, treatment, and disposal services	Waste collection, treatment, and disposal services
Residential building construction	Construction
Non-residential building construction	Construction
Heavy and civil engineering construction	Construction
Construction services	Construction
Basic material wholesaling	Basic material wholesaling
Machinery and equipment wholesaling	Machinery and equipment wholesaling
Motor vehicle and motor vehicle parts wholesaling	Other wholesaling
Grocery, liquor, and tobacco product wholesaling	Other wholesaling
Other goods and commission based wholesaling	Other wholesaling
Motor vehicle and motor vehicle parts retailing	Motor vehicle and motor vehicle parts retailing
Fuel retailing	Fuel retailing
Supermarket and grocery stores	Supermarket and grocery stores

106 IO categories	61 IO categories
Specialised food retailing	Specialised food retailing
Furniture, electrical, and hardware retailing	Other retailing
Recreational, clothing, footwear, and personal accessory retailing	Other retailing
Department stores	Other retailing
Other store-based retailing; non-store and commission based retailing	Other retailing
Accommodation	Accommodation
Food and beverage services	Food and beverage services
Road transport	Road transport
Rail transport	Rail transport
Other transport	Other transport
Air and space transport	Air and space transport
Postal and courier services	Postal and courier services
Transport support services	Transport support services
Warehousing and storage services	Warehousing and storage services
Publishing (except internet and music publishing)	Information media and technology
Motion picture and sound recording activities	Information media and technology
Broadcasting and internet publishing	Information media and technology
Telecommunications services	Information media and technology
Library and other information services	Information media and technology
Banking and financing; financial asset investing	Financial and insurance services
Life insurance	Financial and insurance services
Health and general insurance	Financial and insurance services
Superannuation and individual pension services	Financial and insurance services
Auxiliary finance and insurance services	Financial and insurance services
Rental and hiring services (except real estate); non-financial asset leasing	Rental, hiring and real estate
Residential property operation	Rental, hiring and real estate
Non-residential property operation	Rental, hiring and real estate
Real estate services	Rental, hiring and real estate
Owner-occupied property operation	Owner-occupied property operation
Scientific, architectural, and engineering services	Scientific, architectural, and engineering services
Legal and accounting services	Legal and accounting services
Advertising, market research, and management services	Advertising, market research, and management services
Veterinary and other professional services	Veterinary and other professional services
Computer system design and related services	Computer system design and related services
Travel agency and tour arrangement services	Administrative services
Employment and other administrative services	Administrative services
Building cleaning, pest control, and other support services	Administrative services
Local government administration services	Public administration and defence
Central government administration services	Public administration and defence
Defence	Public administration and defence
Public order, safety, and regulatory services	Public administration and defence
Preschool education	Education and training
School education	Education and training
Tertiary education	Education and training
Adult, community, and other education	Education and training
Hospitals	Health care and social assistance
Medical and other health care services	Health care and social assistance
Residential care services and social assistance	Health care and social assistance
Heritage and artistic activities	Arts and recreation services
Sport and recreation services	Arts and recreation services
Gambling activities	Arts and recreation services
Repair and maintenance	Repair and maintenance
Personal services; domestic household staff	Other services
Religious services; civil, professional, and other interest groups	Other services