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# Modelling the Impact on Livestock Emissions from New Zealand Emissions Pricing and Global Agricultural Action


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Client Report prepared for He Pou a Rangi Climate Change Commission

May 2022

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Saunders, J.T., Guenther, M. & Driver, T. (2022). Modelling the Impact on Livestock Emissions from New Zealand Emissions Pricing and Global Agricultural Action. Report prepared for He Pou a Rangi Climate Change Commission. Lincoln University: Agribusiness and Economics Research Unit.

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# Glossary of terms

## Countries

EU-27 – European Union (27 members)

NZ – New Zealand

UK – United Kingdom of Great Britain and Northern Island

US – The United States of America

## Units

$CO_2e$ – carbon dioxide equivalent

$tCO_2e$ – tonnes carbon dioxide equivalent

t – tonnes

kilo tonnes - (000 t)

million tonnes - (000 000 t)

NZD – New Zealand dollars

USD – United States dollars

## Abbreviations and Acronyms

CAA – competitor agricultural action

GHG – greenhouse gases

HWEN – He Waka Eka Noa

IMAGE – Integrated Model to Assess the Global Environment

LTEM - Lincoln Trade and Environment Model

PBL – PBL Netherland's Environmental Assessment Agency

RCP – Representative Concentration Pathway

SMP – skim milk powder

SSP – Shared Socioeconomic Pathways

WMP – whole milk powder

# 1 Introduction

This report presents the findings of a set of scenario modelling exercises concerning global emissions change and emissions pricing in livestock production using the Lincoln Trade and Environment Model (LTEM).

The aim of these modelling exercises is to illustrate changes on both global and domestic livestock emissions given the implementation of an emissions price on New Zealand livestock production, and depending on whether New Zealand's major export competitors implemented climate change policy action in their own livestock or agricultural sectors. The definition of export competitors for New Zealand's key agricultural exports, and the potential for climate action in agriculture were informed by a previous AERU report (Guenther, Saunders & Driver, 2022).

Of the identified key export competitor countries (Australia, Belgium, Brazil, China, France, Germany, Ireland, Italy, the Netherlands, the UK, and the US), only Australia, Brazil, France, Germany, Ireland, Italy, the Netherlands, and the UK, were deemed to have actionable emissions goals which would entail a reduction in agricultural production before 2050.

The scenarios studied and the assumptions underpinning them are described in Section 2.

## 1.1 Lincoln Trade and Environment Model (LTEM)

The model used in this research, the LTEM, is based upon VORSIM framework (Roningen, 1997). LTEM is a multi-country, multi-commodity partial equilibrium (PE) framework which focuses on the agricultural sector i.e. the linkages of the agricultural sector with the rest of the economy are not considered. The LTEM has been used to assess a number of international and national policy and trade decisions (Saunders & Cagatay, 2004; Revell et al., 2013; Saunders & Saunders, 2015; Saunders et al., 2016) highlighting the implications for NZ agro-producers.

LTEM is used to quantify the price, supply, demand and net trade effects of trade and domestic agricultural support policies. The model is used to derive the long-term policy impact in a comparative static fashion. The included products are treated as homogenous and therefore perfectly substitutable in international markets. It is a non-spatial model in which the framework derives the net trade of each region, however, the supply and demand shares of countries in trade can also be traced down. It allows the application of various domestic and border policies explicitly such as production quotas, set-aside policies, input and/or output related producer subsidies/taxes, consumer subsides/taxes, minimum prices, import tariffs and export subsidies. The economic welfare implications of policy changes are also calculated in the LTEM framework by using the producer and consumer surplus measures.

The LTEM framework includes 26 commodities and 22 countries. These are presented in the appendix (Table A 1 & Table A 2). The dairy sector is modelled as five commodities. Raw milk is defined as the farm gate product and then is allocated to either the liquid milk, butter, cheese, whole milk powder or skim milk powder markets depending upon their relative prices subject to physical constraints. The meat sector is disaggregated into sheepmeat, beef, and pig meat in the current version of LTEM. Six crop products (wheat, maize, rice, sugar, coarse grains, oilseeds, oil meals, oil, apples and kiwifruit) as well as the poultry sector (poultry meat and eggs) and wool are also explicitly modelled in LTEM framework.

The general equation structure of each commodity at country level in LTEM framework is represented by six (eight for crops) behavioural equations and one economic identity as in the equations (1) to (9).

The trade price ($pt$) of a commodity ($i$) in a country ($j$) is determined as a function of world market price ($WDpt_i$) of that commodity and the exchange rate ($ex_j$), equation 1. The total effect of world market price on trade price of the country is determined by the price transmission elasticity. The domestic producer ($pp_{ij}$) and consumer prices ($pc_{ij}$) are defined as functions of trade price of the related commodity and commodity specific production and consumption related domestic support/subsidy policies, ($Zs_j$, $Zd_j$), which are represents the price wedge, equations 2 and 3.

$$pt_{ij} = f\left(WDpt_i, ex_j\right) \tag{1}$$
$$pp_{ij} = g\left(pt_{ij}, Zs_j\right) \tag{2}$$
$$pc_{ij} = h\left(pt_{ij}, Zd_j\right) \tag{3}$$

The domestic supply and demand equations are specified as constant elasticity functions that incorporate both the own and cross-price effects. Domestic supply ($qs_{ij}$) is specified as a function of the supply ($ssft_{ij}$) shifter, which represents the economic factors that may cause shifts, a policy variable ($Z_j$) that may reflect the production quota or set-aside policy, and producer prices of the own and other substitute and complementary commodities ($pp_{ijk}$), equation 4.

$$qs_{ij} = l(ssft_{ij}, Z_j, pp_{ikj}) \tag{4}$$

Domestic demand ($qd_{ij}$) is specified as a function of the demand ($dsft_{ij}$) shifter, consumer prices of the own and other substitute and complementary commodities ($pc_{ijk}$) and per capita real income ($pinc_j$) created in the economy, equation 5. The total demand for crops is separated into feed and food demand (and processing industry demand ($qd_{ij,pr}$) in some cases, equation 6). In feed demand ($qd_{ij,fe}$) function domestic supply of livestock ($qs_{ij,liv}$) sector is also included as an explanatory variable, equation 7.

$$qd_{ij,fo} = m\left(dsft_{ij}, pc_{ikj}, pinc_j\right) \tag{5}$$
$$qd_{ij,fe} = m'\left(dsft_{ij,fe}, pc_{ij}, qs_{ij,liv}\right) \tag{6}$$
$$qd_{ij,pr} = m''\left(dsft_{ij,pr}, pc_{ikj}\right) \tag{7}$$

The stocks ($qst_{ij}$) are determined as a function of the stock shifter ($stsft_{ij}$), quantity supplied ($qs_{ij}$) and consumer price ($pc_{ij}$) of the commodity, equation 8. Finally, net trade ($qt_{ij}$) of the country ($j$) in commodity ($i$) is determined as the difference between domestic supply and the sum of domestic demand (also includes ($qd_{ij,fe}$) and ($qd_{ij,pr}$) in case of crops) and stock changes in the related year, equation 9. LTEM is a synthetic model since the parameters are adopted from the literature.

$$qst_{ij} = n\left(stsft_{ij}, qs_{ij}, pc_{ij}\right) \tag{8}$$
$$qt_{ij} = qs_{ij} - qd_{ij} - \Delta qst_{ij} \tag{9}$$

The model works by simulating the commodity based world market clearing price on the domestic quantities and prices, which may or may not be under the effect of policy changes. Excess domestic supply or demand in each country spills over onto the world market to determine world prices. The world market clearing price is determined at the level that equilibrates the total demand and supply of each commodity in the world market.

# 2 Scenarios

Seven scenarios were selected to assess change over three dimensions, action on livestock emissions by some of New Zealand's competitors, the implementation of an emissions price, and the level of assistance offered by the New Zealand government for producers of livestock goods. The intention of this scenario analysis is to assess the relationship between action on agricultural emissions by New Zealand's competitors and domestic agricultural emissions policies.

Table 1 lists the chosen scenarios. The first scenario, the baseline, represents business as usual, no change in domestic or international policy around emissions pricing or reductions. This (and all scenarios) include a background of changes under RCP 4.5/ SPS 2 taken from the PBL's IMAGE model (Stehfest et al., 2014). This scenario is used as a comparator for the subsequent scenarios, helping isolate the changes which have been brought on from the scenarios, rather than those from the general projection of New Zealand's agricultural production and interaction with global markets over time.

Scenarios 1-3 assume New Zealand competitor action on agricultural emissions is taken by New Zealand's competitors in line with the findings of the AERU literature review (2022). Where New Zealand's competitors had stated agricultural emissions reductions targets, these were assumed reached by the stated date. Of those competitor's examined, only Australia, Brazil, the European Union (in particular Belgium, France, Germany, Italy, Ireland, and the Netherlands), and the United Kingdom, were deemed to have quantifiable agricultural goals or targets for emissions reductions which would impact on production for livestock commodities. While it is unknown whether these countries will be able to meet these goals and targets in actuality, by modelling the fullest and least extent by which these countries achieve these goals, we can assess the range of possible outcomes competitor action on emissions will have on global markets. If these countries were to only partial meet some of these outcomes, or only some of these countries were to achieve these outcomes, the resulting impact would fall somewhere between those shown in the scenarios which assume competitor action on livestock emissions versus those without competitor action.

It is also important to note the assumed changes in competitor agricultural action were only applied to the livestock sectors of focus to this report (sheepmeat, beef, and dairy).

Conversely, scenarios 4-7 assume no competitor action on agricultural emissions reduction outside of New Zealand, and thus New Zealand's competitors have no modelled policy constraints on their potential for growth in agricultural production.

The difference between scenarios 2-4, and 5-7 is the extent to which the New Zealand government offers assistance. Scenarios 2 and 5 assume 95 per cent of the initial emissions price in 2025 is offset which then decreases by 1 per cent year on year (HWEN, 2022). This implies a remaining burden of 4.25 NZD per tonnes of $CO_2$e in 2025, rising to 13.8 NZD/t$CO_2$e in 2030 and then 41.4 NZD/t$CO_2$e in 2050.

Scenarios 3 and 6 assume a 60 per cent starting level of assistance, which again decreases by 1 per cent year on year. This implies a remaining burden of 34.0 NZD per tonnes of $CO_2$e in 2025, rising to 62.1 NZD/t$CO_2$e in 2030 and then 89.7 NZD/t$CO_2$e in 2050.

Finally, scenarios 4 and 7 assume no government assistance offsetting the emissions price. As of such, producers are assumed to pay the entirety of the emissions price, set at 85 NZD per tonnes of $CO_2$e in 2025, rising to 138 NZD/t$CO_2$e in 2030 and continuing until 2050.

**Table 1: Scenario list**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 1 | Baseline | none | N/A | none |
| 2 | High assistance/CAA | high | 95% decreasing 1% yearly | As HWEN |
| 3 | Med assistance/CAA | high | 60% decreasing 1% yearly | As HWEN |
| 4 | No assistance/CAA | high | none | As HWEN |
| 5 | High assistance | none | 95% decreasing 1% yearly | As HWEN |
| 6 | Med assistance | none | 60% decreasing 1% yearly | As HWEN |
| 7 | No assistance | none | none | As HWEN |

**Notes**

**Competitor Agricultural Action (CAA):**

- High – 100% of agricultural climate commitments reached
- None – no agricultural climate commitments

**Method of assistance:**

- level of assistance is proportional discount

Total emissions are a factor of average emissions factors taken from the FAO (FAOSTAT, 2022) where appropriate. Total emissions are an output of the modelling and may differ from national greenhouse gas inventory totals.

**Emissions Price**

The emissions price used in the modelling exercise was aligned with those presented in the February 2022 He Waka Eka Noa consultation document. In the modelling scenarios with the emissions price (scenarios 2-7), the emissions price is introduced at 85 NZD per tonne of $CO_2e$ in 2025, gradually increases to 138 NZD per tonne of $CO_2e$ in 2030 and remains at this level until 2050, the final year of the modelling (Table 2).

**Table 2: Progression of the modelled emissions price over time**

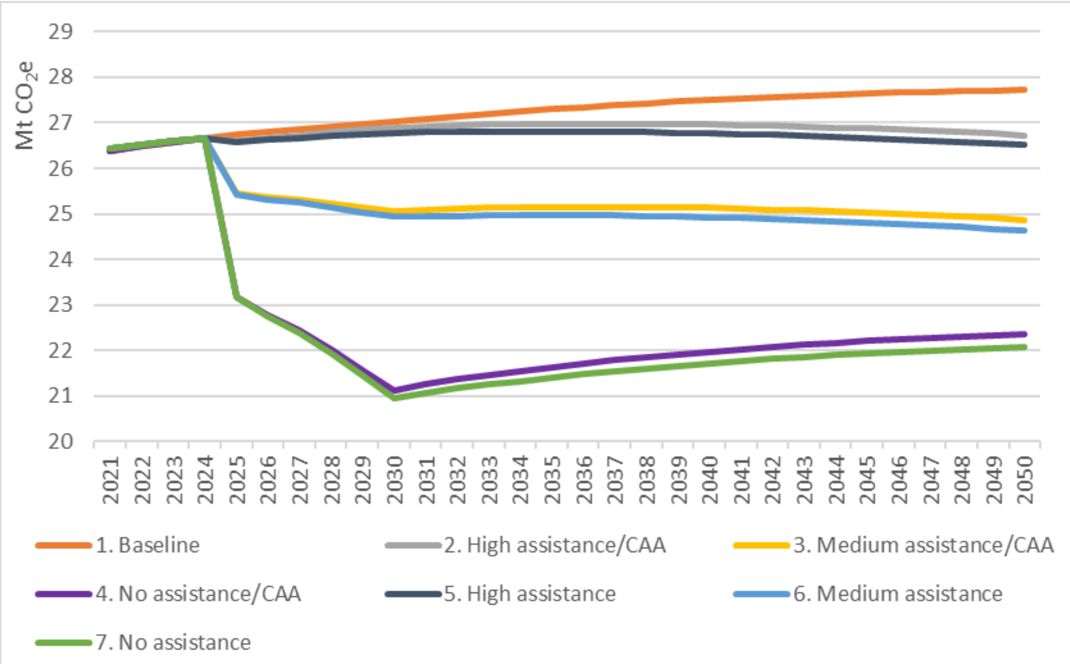
| Period | Emissions Price ($/t) |
|---|---|
| 2025 | $85 |
| 2030 | $138 |
| 2040 | $138 |
| 2050 | $138 |

Individual scenario results are presented as the difference between the Baseline scenario (1) and the presented scenario, year on year. Domestic producer prices are presented as net price with emissions price embodied, i.e. producer price minus the un-assisted price of emissions.

# 3 Cross Scenario Comparisons – Domestic

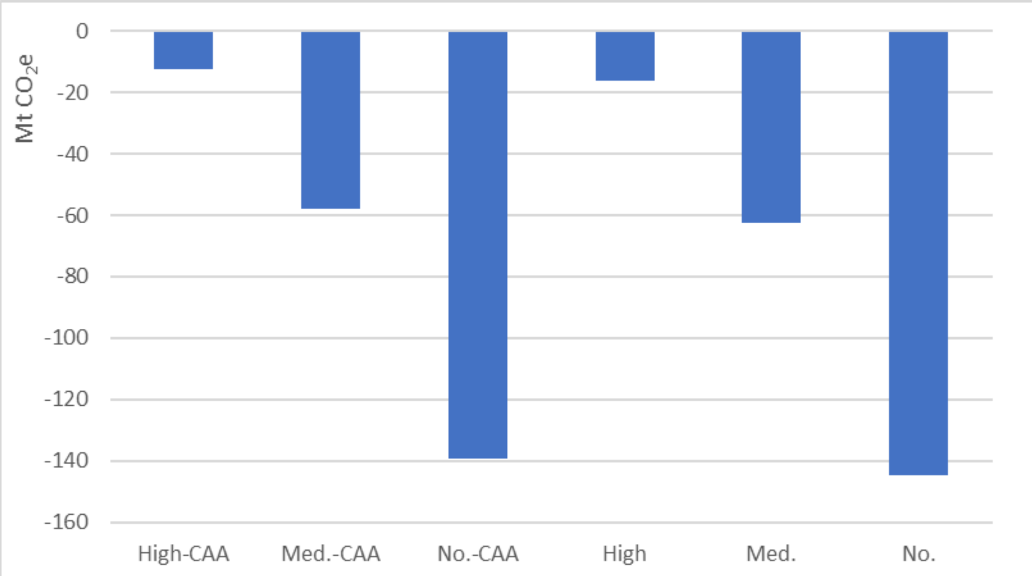
As can be seen in Figure 1, the outcome for New Zealand's livestock emissions falls into three major tranches, depending on the level of assistance offered relative to the price of emissions. The reduction from the baseline in 2050 is equivalent to between 1.0-1.2 $MtCO_2e$ with high assistance, 2.9-3.1 $MtCO_2e$ with medium assistance and 5.4-5.6 $MtCO_2e$ with no assistance.

**Figure 1: Cross-scenario comparison of New Zealand emissions (dairy & red meat)**




The total extent of these changes over the modelled period (2021-2050) is shown in Figure 2, where the total reduction over the 29-year period is 12.3-16.2 $MtCO_2e$ with high assistance, 57.9-62.4 $MtCO_2e$ with medium assistance and 139.1-144.6 $MtCO_2e$ with no assistance.

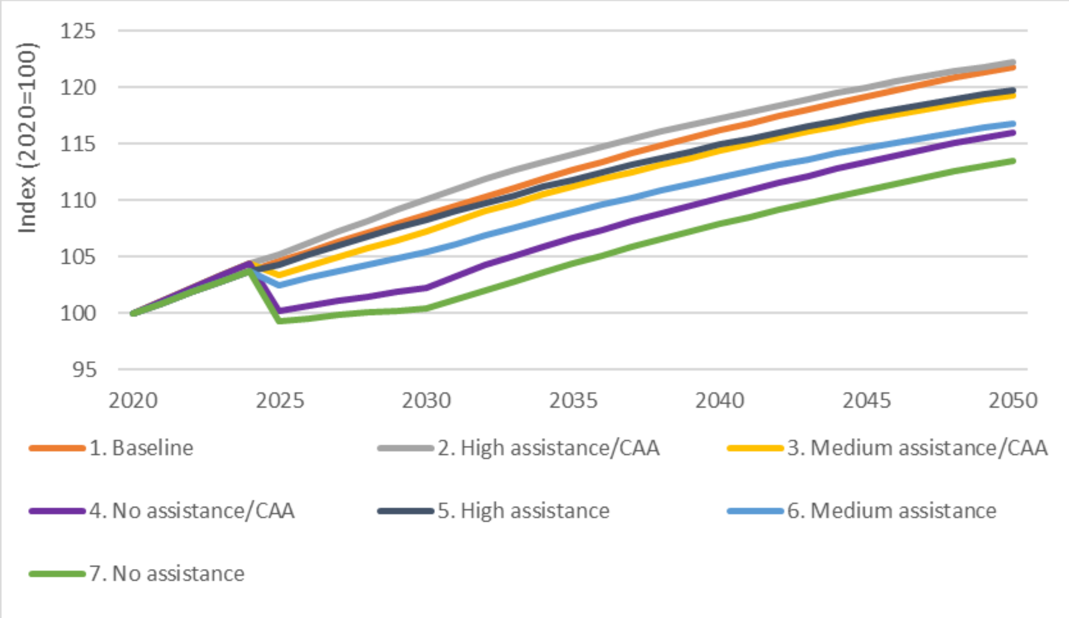
**Figure 2: Total change in New Zealand red meat and dairy emissions: 2021-2050**




These results indicate the success of the New Zealand emissions price at reducing livestock emissions under all settings, regardless of whether New Zealand's trading competitors achieve their goals for emissions reductions in the agricultural sector.

Looking at dairy prices for New Zealand (Figure 3), dairy prices in the high assistance/Competitor Agricultural Action scenario (2) are higher than those in the baseline scenario. The reason for this somewhat counter-intuitive result is New Zealand's significance in global dairy markets. The addition of emissions pricing causes an initial constraint to New Zealand dairy production. This constraint, in turn, causes world dairy prices to increase. Ultimately the balance of higher world prices off-sets the low cost of emissions pricing under the high assistance scenario, thus allowing some dairy production in New Zealand to increase (as shown in more detail in the complete results for scenario 2). This implies higher somewhat higher emissions from the dairy sector. Total New Zealand livestock emissions still decrease due to reductions in the production of beef and sheepmeat, although beef also shows some price gains from competitor action (Figure 4), albeit to a lesser extent than for dairy.

**Figure 3: Cross Scenario comparison of New Zealand producer price for dairy**



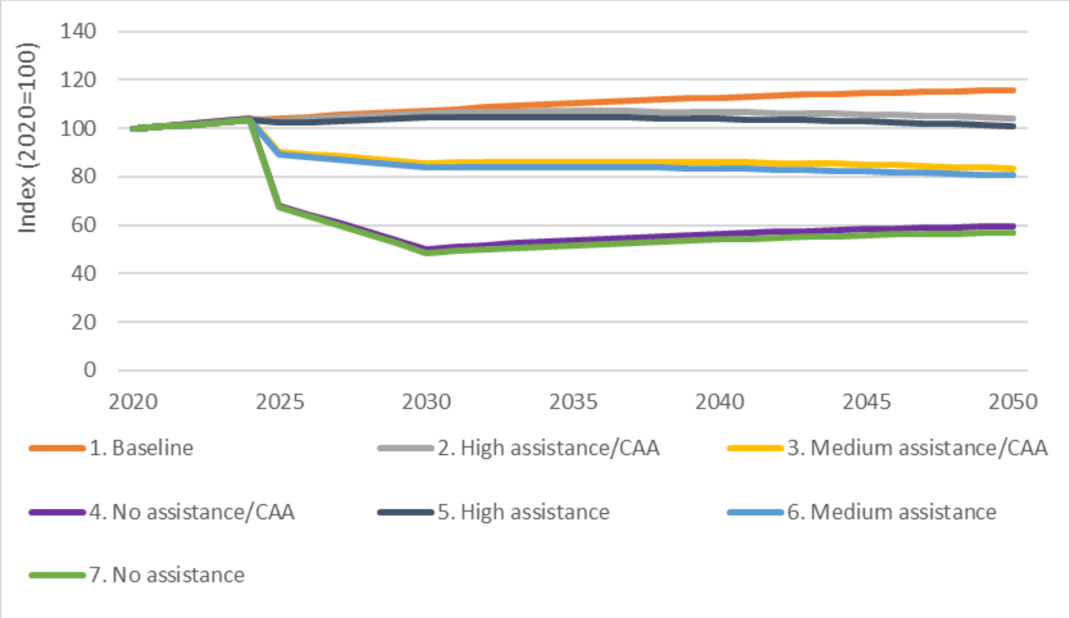

NB: emissions-price embodied

Conversely the scenario with only high assistance and no international change (scenario 5), producer prices are below the baseline level. Essentially competitor agricultural action implies higher world prices for dairy as other countries are constrained. Medium assistance with competitor agricultural action (scenario 3) is comparable to the high assistance with no competitor agricultural action scenario (#5) for example.

As expected, all other scenarios have lower prices for dairy, beef, and sheepmeat than seen in the baseline. The most extreme, no assistance scenario (#7), implies a seven per cent decrease in dairy prices by 2050, equivalent to an average annual loss of 12.4 billion USD in producer returns (Table 32).

Producer prices for beef and sheep are more heavily effect under the various scenarios. Under, the no assistance scenario (#7) beef prices decrease by over 50 per cent in 2050, an equivalent of 10.6 billion USD lost annually in producer returns. For Sheepmeat this is a 40 per cent reduction in producer prices, and 13 billion USD less than in the baseline annually (Table 32).

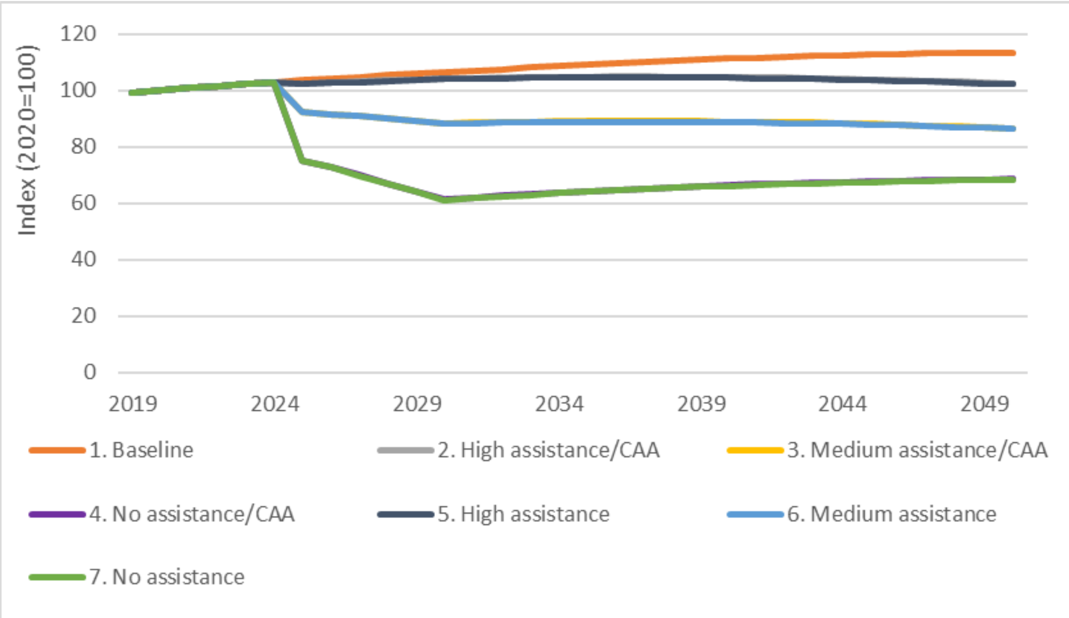
**Figure 4: Cross Scenario comparison of New Zealand producer price for beef**




NB: emissions-price embodied

The influence of competitor agricultural action on domestic producer prices is less significant in the case of Beef, as shown in Figure 4, and sheepmeat, as shown in Figure 5.

**Figure 5: Cross Scenario comparison of New Zealand producer price for sheepmeat**

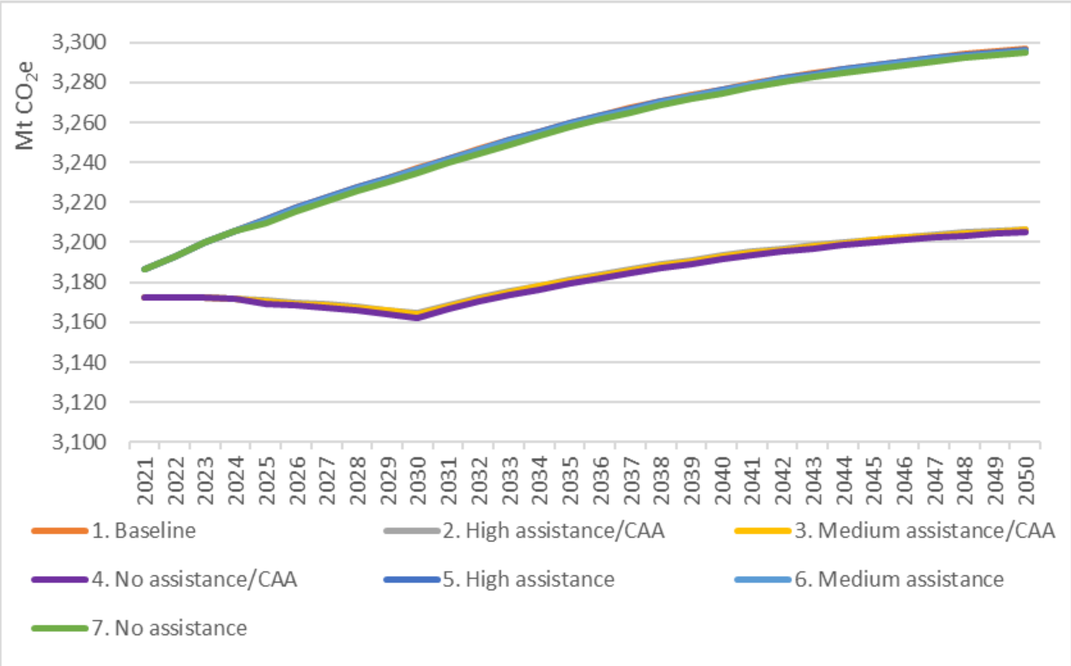



NB: emissions-price embodied

# 4 Cross Scenario Comparisons - International

This section deals with the consequences for global livestock emissions from New Zealand and its trade competitor's policy decisions; Figure 6 showing the total emissions for red meat and dairy production globally by scenario. The results are split between two major groupings, dependant on whether competitor action for emissions reduction in the livestock sector is achieved by New Zealand's competitors or not. Competitor action accounts for a global decrease of between 90.0-91.6 $MtCO_2e$ in 2050, depending on New Zealand's level of assistance in emissions pricing. The impact of New Zealand's emissions pricing on global emissions is minimal, thus the change between scenarios 2-4 and 1, 5-7 is difficult to discern compared to global changes from competitor agricultural action.

**Figure 6: Global red meat and dairy emissions by scenario**




In terms of total emissions, no scenarios show increases in global livestock emissions beyond those in the baseline scenario. Even in the most drastic domestic change scenario with no assistance (scenario 7). The more detailed results for scenario 7 show that in term of production deferral, as shown in Figure 32 and Figure 33, no singular country is expected to fulfil the production decreases from New Zealand. Furthermore, the lack of global increases in livestock emissions, indicates that this increased production is not taken up by countries with lesser emissions intensity to any significant degree. This is, of course, dependant on the assumed emissions factors informing the modelling exercise.

If we assume competitor agricultural action, then there is some additional deferral of global production as New Zealand's traditional competing exporters are less able to contribute to replacing lost New Zealand product in global markets. Scenario 4, 'No assistance/Competitor Agricultural Action', implies the highest lost production in New Zealand and its trade competitors. Here, China, India, and the United States are the main countries supplanting lost global livestock production (Figure 20 and Figure 21). In particular, the United States becomes a greater exporter of cheese, skim milk powder, and beef. China increases its production of whole milk powder, sheepmeat, and beef, while India increases butter production, and to a lesser extent sheepmeat. These changes, however, do not imply greater global livestock emissions.

While total greenhouse gases decrease in all scenarios, it is important to note that all scenarios show a decrease in global production for all examined commodities. Thus, not all lost production is deferred to third-party producers. This will imply higher world prices not reflected in New Zealand's producer prices (due to the embodied cost of the emissions price) and thus costs for global consumers. For example, domestic consumer spending in scenario 4 (No assistance/Competitor Agricultural Action) increases by 1,728 million USD for red meat, and 5,789 million USD for dairy. This is equivalent to 59.6 and 199.6 million USD annually respectively. Furthermore, higher prices may imply additional growth in third party country's production beyond the final year of the model's projections (2050).

**Figure 7: Global red meat and dairy emissions change from baseline**

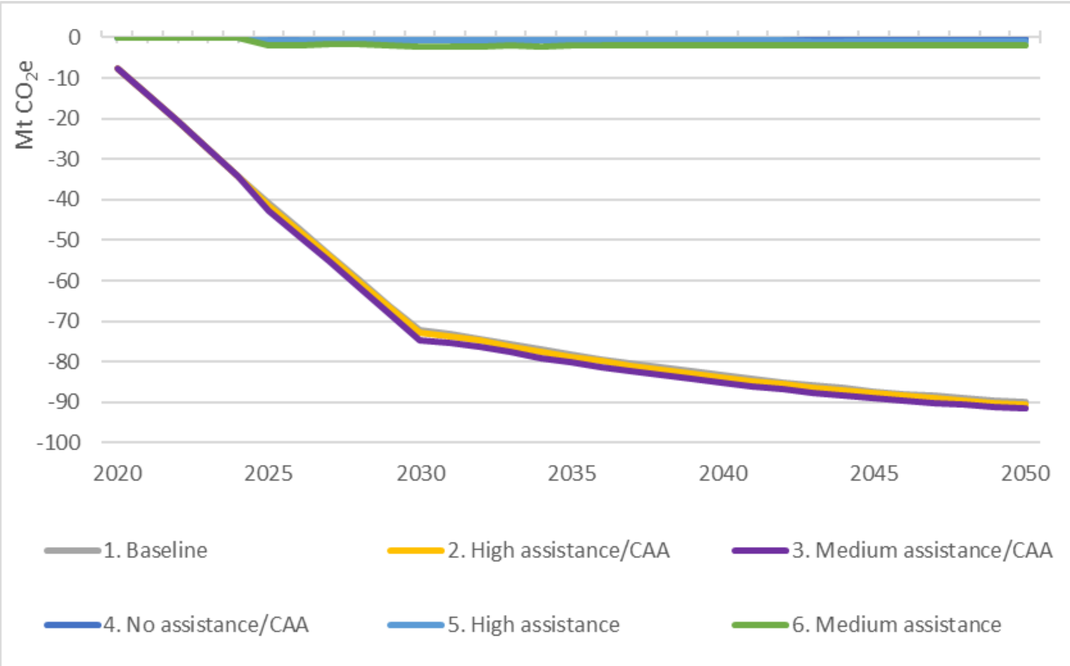



Figure 7 and Figure 8 show the changes in global emissions comparative to the baseline scenario. Demonstrating the lower overall emissions in all scenarios. Total global livestock emissions are projected to decrease between 2,095.2-2,143.9 $MtCO_2e$ with competitor action, and between 4.7-52.0 $MtCO_2e$ with only domestic emissions pricing.

**Figure 8: Total change in global red meat and dairy emissions: 2021-2050**

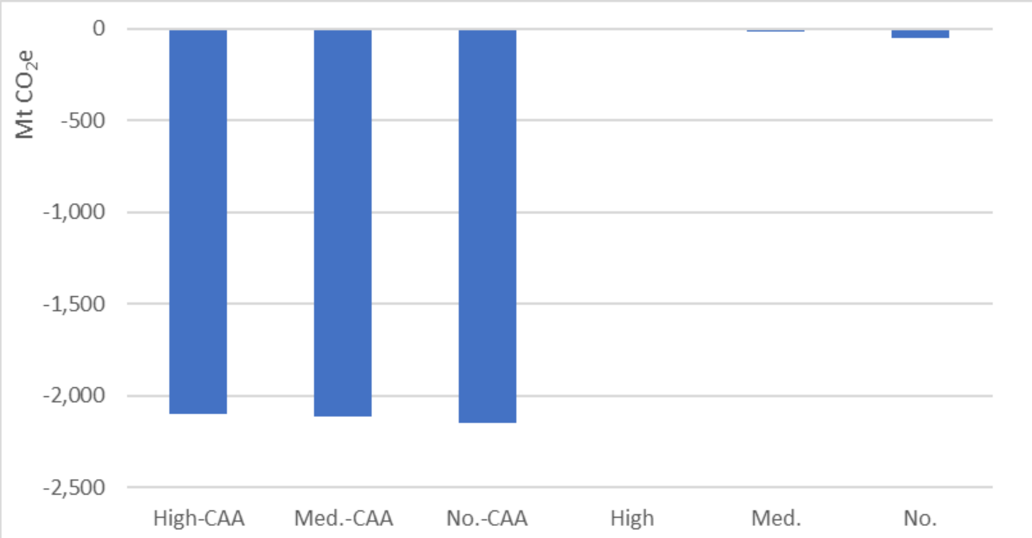
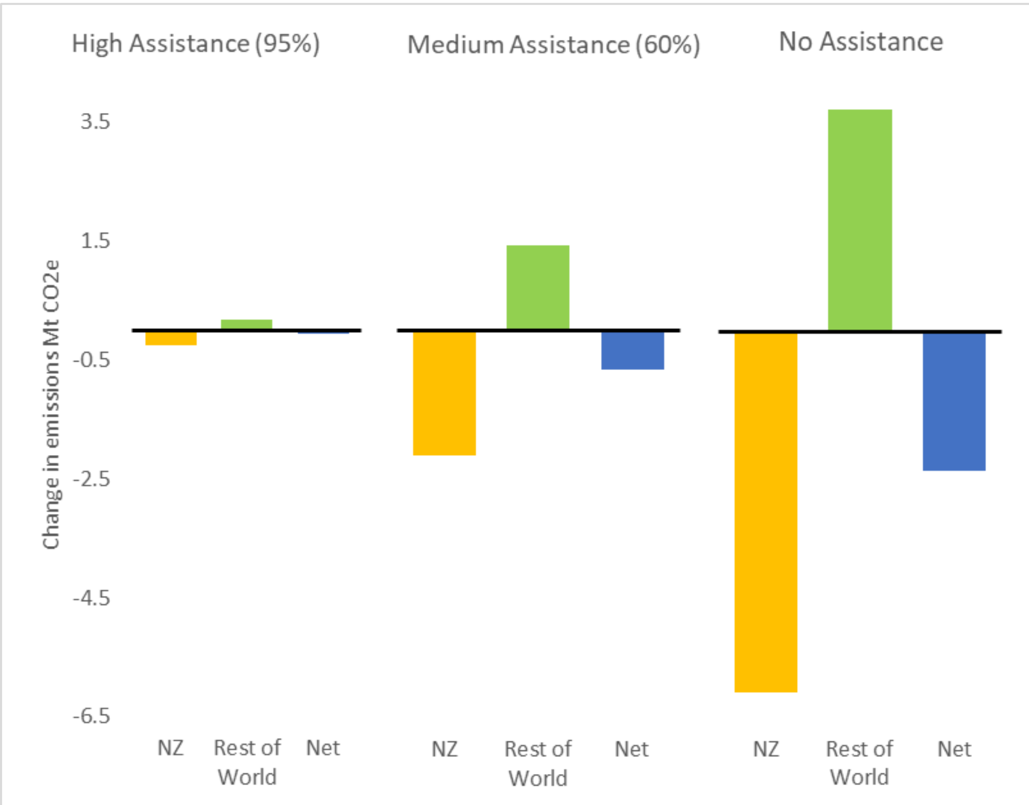



Figure 9 shows the relative change in emissions between sources for scenarios 5-7. As can be seen, emissions in other countries do increase given the implementation of an emissions price in New Zealand. However, not to the extent that global emissions increase. This is largely due to global production decreasing, as other countries do not completely replace New Zealand's production deficit during the modelled period (2021-2050).

**Figure 9: Change in emissions, New Zealand and the Rest of the World in 2030**



The OCED (2021) provides a simple methodology for assessing emissions leakage rates. The sum of increases in emissions in countries without emissions policies over the sum of decreases in countries with emissions policies. The resulting emissions rate demonstrates whether an external increase in emissions has occurred, with a leakage rate of over 100 per cent implying an increase in total emissions as a result of the changes in a given scenario.

Table 3 shows the leakage rates for the different scenarios compared to the baseline scenario, with scenarios 2-4 comparing the change in emissions in New Zealand and its competitors with change in all other countries; while scenarios 5-6 compare change in New Zealand emissions with the change in all other countries (including its competitors). The results show that no scenario has an increase in global emissions and that leakage rates are increasing, albeit slowly, leading up to 2050.

Interestingly, scenario 5 (High assistance) has the highest leakage rate of the scenarios which do not assume competitor action. This is a result of other countries being slow to replace the production decrease from New Zealand producers. Thus, scenarios which imply a higher decrease in New Zealand production (such as scenarios 6 & 7) will have a greater deficit in global production and thus emissions.

**Table 3: Leakage rates for each scenario**

| | 2021 - 2025 | 2026 - 2030 | 2031- 2035 | 2036- 2040 | 2041- 2045 | 2046- 2050 | 2021- 2050 |
|---|---|---|---|---|---|---|---|
| Extra-New Zealand & Competitors leakage rates | | | | | | | |
| 2. High assistance/CAA | 0% | 4% | 6% | 6% | 7% | 7% | 6% |
| 3. Medium assistance/CAA | 1% | 5% | 7% | 8% | 8% | 8% | 7% |
| 4. No assistance/CAA | 1% | 7% | 9% | 9% | 9% | 9% | 9% |
| Extra-New Zealand leakage rates | | | | | | | |
| 5. High assistance | 9% | 69% | 70% | 71% | 72% | 72% | 71% |
| 6. Medium assistance | 9% | 67% | 71% | 71% | 70% | 70% | 69% |
| 7. No assistance | 9% | 61% | 65% | 65% | 65% | 65% | 64% |

Emission's leakage in the first period (2021-2025) are lower as they includes the period before emissions prices are introduced (2021-2024).

# 5 Scenario 2: High Assistance/Competitor Agricultural Action

**Table 4*: Scenario 2* assumptions**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 2 | High assistance/CAA | high | 95% decreasing 1% yearly | As HWEN |

This scenario (Table 4) assumed high assistance for NZ producers with 95 per cent of the emissions price subsidised by the government at its implementation in 2030 and a subsequent drop of assistance by 1 per cent annually. In addition, global climate level is high. It is assumed that Brazil, EU-27, the UK and Australia fully achieve their agricultural climate commitments.

Table 5 shows modelling projections for world production by commodity over the projection period 2021 – 2050. Global meat and dairy production is predicted to decrease significantly for all commodities due to the high global climate action, which has a significant impact on the reduction of livestock production.  The largest fall in production by 2050 is projected for global beef production (- 12.0 million tonnes), followed by cheese (- 7.2 million tonnes), then WMP production (-2.8 million tonnes).

**Table 5: *Scenario 2* -World Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | 492 | -954 | -2,174 | -2,714 | -3,158 | -3,528 | -12,035 |
| Sheepmeat | -12 | -44 | -77 | -122 | -166 | -210 | -631 |
| Butter | -68 | -148 | -214 | -229 | -240 | -248 | -1,147 |
| Cheese | -448 | -950 | -1,363 | -1,443 | -1,495 | -1,533 | -7,233 |
| WMP | -183 | -361 | -513 | -554 | -587 | -617 | -2,814 |
| SMP | -52 | -112 | -165 | -179 | -189 | -198 | -895 |
| Meat | 247 | -1,193 | -2,428 | -2,967 | -3,422 | -3,816 | -13,579 |
| Dairy | -752 | -1,572 | -2,255 | -2,404 | -2,510 | -2,597 | -12,089 |

For NZ, modelling results show that domestic meat production is expected to drop by 1.4 billion tonnes between 2021 and 2050 (see Table 6). Larger decreases are predicted for beef production than sheepmeat production. Interestingly, under this scenario, NZ dairy production is expected to increase by 371 kilo tonnes by 2050. This is due to the large global reduction in dairy production leading to higher world prices for dairy products, which helps offset the price paid by NZ producers for emissions. It can be seen that the increases in domestic dairy production level off as the NZ emissions price increases leading up to 2030, and as the government assistance tails off. However, production levels are still positive and higher than in the baseline scenario.

**Table 6: *Scenario 2* -New Zealand Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -15 | -34 | -58 | -113 | -172 | -235 | -628 |
| Sheepmeat | -4 | -50 | -96 | -161 | -229 | -300 | -840 |
| Butter | 6 | 10 | 13 | 8 | 3 | -3 | 37 |
| Cheese | 6 | 12 | 17 | 15 | 14 | 12 | 75 |
| WMP | 22 | 37 | 48 | 42 | 34 | 26 | 209 |
| SMP | 6 | 11 | 14 | 10 | 7 | 3 | 50 |
| Meat | -19 | -82 | -151 | -268 | -392 | -523 | -1,434 |
| Dairy | 40 | 70 | 92 | 76 | 57 | 37 | 371 |

The projected decrease in producer prices and production leads to decreases in New Zealand producer returns for the two meat commodities. As shown in Table 7, NZ producer returns for meat are projected to drop by 7.6 per cent by 2050. Interestingly, producer returns for all dairy commodities are expected to grow by 2050. Producer returns are projected to increase up to 2.3 per cent between 2021 and 2035 but then, with the gradual introduction of the higher price for emissions in 2030, producer returns are dropping slightly, however they are still positive and higher than returns in the baseline scenario which is an interesting result. Overall, between 2021 and 2050 producer returns for dairy are projected to increase by almost 2 per cent with the highest returns projected for cheese (+2.6 per cent), then WMP (+2.2 per cent) by 2050.

**Table 7: *Scenario 2* -New Zealand producer returns (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -819 | -2,141 | -3,850 | -7,238 | -10,903 | -14,756 | -39,706 |
| Sheepmeat | -394 | -3,582 | -7,071 | -11,964 | -17,067 | -22,301 | -62,379 |
| Butter | 647 | 1,042 | 1,254 | 610 | -140 | -954 | 2,458 |
| Cheese | 1,044 | 2,114 | 2,985 | 2,869 | 2,647 | 2,371 | 14,031 |
| WMP | 3,598 | 6,297 | 8,461 | 7,669 | 6,604 | 5,408 | 38,037 |
| SMP | 1,042 | 1,930 | 2,692 | 2,300 | 1,770 | 1,149 | 10,883 |
| Meat | -1,201 | -5,658 | -10,806 | -19,027 | -27,738 | -36,769 | -101,199 |
| Dairy | 6,331 | 11,384 | 15,392 | 13,447 | 10,880 | 7,974 | 65,408 |
| % change from base scenario | | | | | | | |
| Beef | -1.2% | -2.8% | -4.7% | -8.3% | -11.9% | -15.5% | -7.9% |
| Sheepmeat | -0.4% | -3.5% | -6.4% | -10.2% | -13.8% | -17.3% | -9.2% |
| Butter | 0.5% | 0.8% | 0.9% | 0.4% | -0.1% | -0.6% | 0.3% |
| Cheese | 1.3% | 2.5% | 3.4% | 3.1% | 2.8% | 2.5% | 2.6% |
| WMP | 1.5% | 2.4% | 3.0% | 2.6% | 2.1% | 1.6% | 2.2% |
| SMP | 0.9% | 1.4% | 1.8% | 1.5% | 1.0% | 0.6% | 1.2% |
| Meat | -0.6% | -2.8% | -4.9% | -8.2% | -11.5% | -14.8% | -7.6% |
| Dairy | 1.1% | 1.8% | 2.3% | 1.9% | 1.5% | 1.0% | 1.6% |

Under this scenario, modelling projections show an increase in New Zealand consumer spending for livestock commodities by 2050 (see Table 8). The increase in consumer spending for dairy commodities is predicted to be significantly higher than those for meat commodities. Spending on dairy commodities is predicted to increase by 5 billion USD by 2050 compared to the baseline, whereas spending on meat commodities is expected to grow by 902 million USD by 2050 compared to the baseline.

**Table 8: *Scenario 2* -New Zealand consumer spending (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -18 | 41 | 92 | 117 | 137 | 154 | 524 |
| Sheepmeat | -6 | 22 | 46 | 60 | 73 | 84 | 280 |
| Butter | 36 | 79 | 113 | 119 | 122 | 124 | 593 |
| Cheese | 93 | 208 | 310 | 337 | 356 | 372 | 1,676 |
| WMP | 4 | 8 | 12 | 13 | 13 | 14 | 64 |
| SMP | 141 | 318 | 483 | 540 | 587 | 628 | 2,698 |
| Meat | -23 | 75 | 158 | 199 | 233 | 261 | 902 |
| Dairy | 274 | 613 | 917 | 1,008 | 1,078 | 1,139 | 5,030 |

As a result of the predicted fall in meat and dairy production and high global climate action of competitor countries, NZ GHG emissions from the two livestock types are expected to decrease over time as shown in Figure 10. This shows that climate policies assumed under this scenario are successful in reducing livestock emissions. Figure 10 also shows that, in line with the projected dairy production increase, described earlier, emissions are projected to increase up to 2030. Once the price for emissions is implemented emissions are projected to decrease and are especially falling after the introduction of the higher emissions price in 2030, and with the gradual removal of government assistance.

**Figure 10: *Scenario 2* - New Zealand emissions for dairy & red meat**

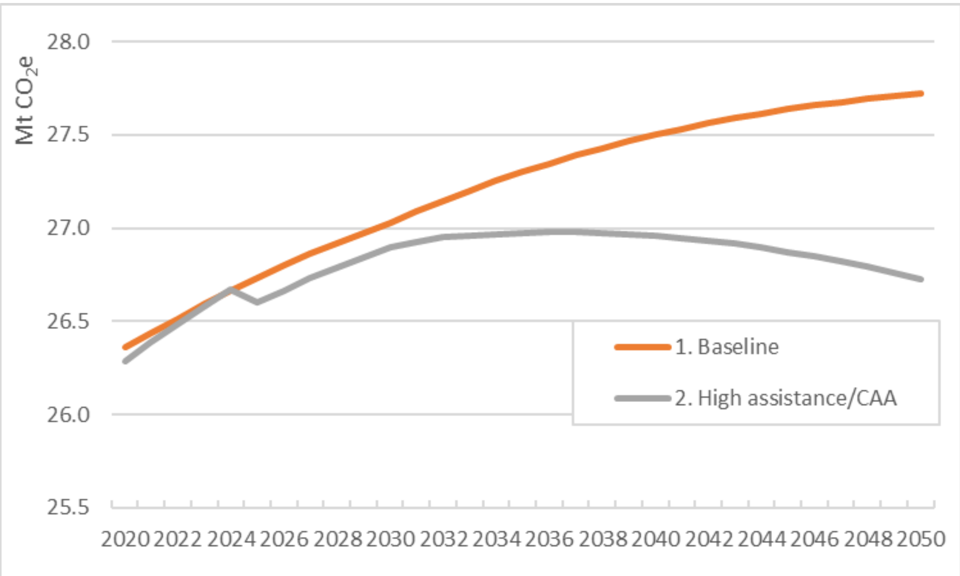
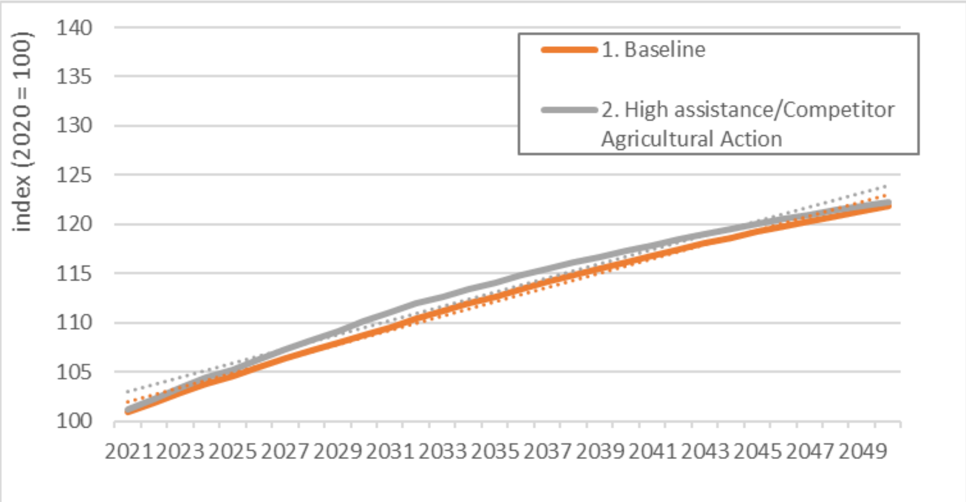


Figure 11 shows projections of the NZ dairy price between 2021 and 2050. Under this scenario, NZ dairy prices are expected to be higher than prices under the baseline scenario. Although they begin to trend below the baseline levels near the end of the modelling exercise in 2050. These high dairy prices are due to global action, and the lower burden of emissions pricing due to the high assistance, as the assistance decreases and other countries increases production in response to higher global prices, NZ producer prices begin to decline.

**Figure 11: *Scenario 2* - New Zealand producer price for dairy**




NB: emissions-price embodied

Figure 12 shows modelling results with regards to the deferral of global meat production in 2050 for two meat commodities. Overall, global sheepmeat and beef production are expected to decrease by 2050. This decrease is predominately projected for the EU-27, New Zealand and Brazil due to their high level of climate action assumed under this scenario. China, India, Australia and the United States are the main countries supplanting lost global meat production. In particular, China becomes a greater producer of sheepmeat and beef while the United States is expected to produce more beef.

**Figure 12: *Scenario 2* - Deferral of global meat production in 2050**

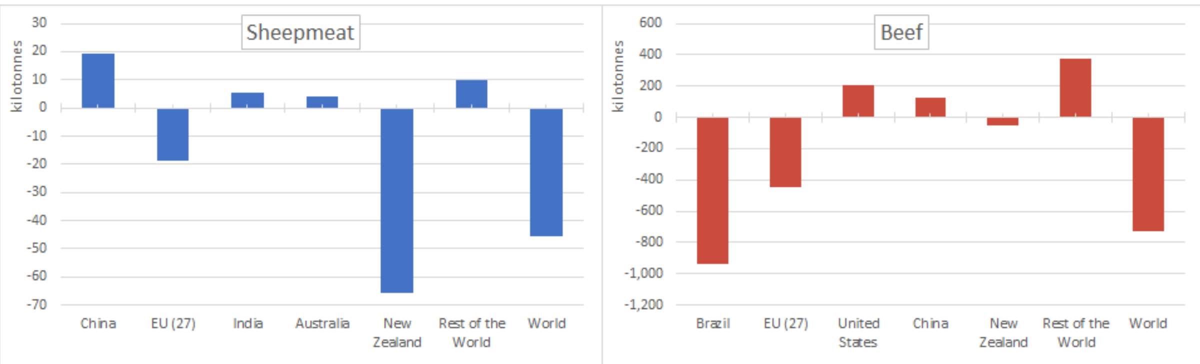



Figure 13 shows the deferral of global dairy production by 2050 for four dairy commodities. As described earlier, global production of all dairy commodities is expected to decrease under this scenario with the largest decrease projected for cheese production. Large falls in dairy production are projected for Brazil and the EU-27 in 2050 due to their high level of climate action. Although other third-party producers are picking up lost dairy production, not all lost production is deferred to third-party producers. Here, India, the US, China and Argentina are the main countries supplanting lost global dairy production. In particular, the United States is expected to become a greater producer of cheese, butter and skim milk powder. China is projected to increase its production of whole milk powder, while India is expected to rise butter production significantly by 2050. Also, NZ production of whole milk powder, cheese and skim milk powder is slightly increased in 2050 compared to the baseline, again due to higher world prices implied by the global deficit.

**Figure 13:** ***Scenario 2*** **-Deferral of global dairy production in 2050**

# 6 Scenario 3: Medium Assistance/Competitor Agricultural Action

**Table 9: *Scenario 3* assumptions**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 3 | Med assistance/CAA | high | 60% decreasing 1% yearly | As HWEN |

This scenario (Table 9) assumed medium assistance for NZ producers with 60 per cent of the emissions price subsidised by the government from 2025 and a subsequent drop of assistance by 1 per cent annually. Also, under this scenario, global action for emissions reduction in the livestock sector is achieved by New Zealand's competitors (Brazil, EU-27, the UK and Australia).

Table 10 shows model projections on world production by commodity over the projection period 2021-2050. Results show a significant decrease in global production for all examined commodities due to the high level of global climate action assumed under this scenario. The largest production drop is projected for beef (- 13.0 million tonnes), followed by cheese (- 7.3 million tonnes), then WMP (-3.0 million tonnes) by 2050.

**Table 10: *Scenario 3* -World Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | 477 | -1,107 | -2,378 | -2,922 | -3,370 | -3,746 | -13,047 |
| Sheepmeat | -40 | -253 | -324 | -373 | -423 | -472 | -1,884 |
| Butter | -71 | -164 | -233 | -248 | -259 | -267 | -1,242 |
| Cheese | -449 | -956 | -1,372 | -1,452 | -1,504 | -1,543 | -7,275 |
| WMP | -186 | -385 | -543 | -583 | -616 | -647 | -2,961 |
| SMP | -54 | -127 | -182 | -196 | -207 | -215 | -981 |
| Meat | 209 | -1,494 | -2,802 | -3,350 | -3,814 | -4,219 | -15,470 |
| Dairy | -760 | -1,632 | -2,330 | -2,480 | -2,585 | -2,672 | -12,459 |

For New Zealand, modelling results predicted meat and dairy production to decrease by 2050 as shown in Table 11. This is due to the higher pricing burden on NZ producers. In particular sheepmeat production is predicated to fall by 3 million tonnes by 2050, followed by beef production which is expected to fall by 2.9 million tonnes by 2050. Domestic dairy production is expected to fall slightly by 2050 with largest drops projected for butter (-185 kilo tonnes), then WMP (-159 kilo tonnes). This is in contrast to results from Scenario 2 where dairy production was predicted to increase by 2050 despite the introduction of the emissions price in 2025 which however was highly supported by the government. There is a similar occurrence of higher world prices for dairy, but unlike with high assistance, this does not totally offset the emissions pricing with medium government assistance assumed under this scenario.

**Table 11:** ***Scenario 3*** **-New Zealand Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -49 | -367 | -505 | -570 | -639 | -713 | -2,842 |
| Sheepmeat | -42 | -399 | -526 | -600 | -677 | -757 | -3,001 |
| Butter | 2 | -25 | -32 | -37 | -43 | -49 | -185 |
| Cheese | 5 | -2 | -1 | -2 | -4 | -6 | -11 |
| WMP | 14 | -23 | -26 | -33 | -41 | -50 | -159 |
| SMP | 3 | -16 | -19 | -22 | -26 | -30 | -111 |
| Meat | -88 | -745 | -1,005 | -1,141 | -1,284 | -1,434 | -5,697 |
| Dairy | 23 | -66 | -78 | -95 | -114 | -135 | -465 |

Lower NZ producer prices due to the pricing of emissions and the subsequent drop in production lead to decreased NZ producer returns from meat and dairy commodities by 2050 (Table 12). Modelling results show significant drops in beef and sheepmeat returns which are predicted to fall by 31 per cent each by 2050 compared to the baseline. Dairy returns are predicted to fall slightly by 1.5 per cent by 2050 with the highest decrease predicted for butter returns (-3 per cent), then SMP (-2 per cent).

**Table 12:** ***Scenario 3*** **-New Zealand producer returns (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -3,281 | -20,948 | -27,373 | -31,245 | -35,229 | -39,296 | -157,374 |
| Sheepmeat | -3,471 | -27,282 | -35,892 | -41,445 | -46,991 | -52,458 | -207,539 |
| Butter | 34 | -3,413 | -4,244 | -5,046 | -5,936 | -6,880 | -25,485 |
| Cheese | 760 | 49 | 450 | 281 | 13 | -305 | 1,247 |
| WMP | 2,287 | -3,125 | -3,100 | -4,210 | -5,560 | -7,017 | -20,725 |
| SMP | 421 | -2,502 | -2,752 | -3,316 | -4,001 | -4,764 | -16,915 |
| Meat | -6,683 | -47,754 | -62,664 | -72,032 | -81,506 | -90,982 | -361,621 |
| Dairy | 3,502 | -8,992 | -9,646 | -12,291 | -15,484 | -18,966 | -61,877 |
| % change from base scenario | | | | | | | |
| Beef | -4.6% | -27.2% | -33.2% | -35.8% | -38.5% | -41.3% | -31.2% |
| Sheepmeat | -3.7% | -26.7% | -32.5% | -35.2% | -37.9% | -40.7% | -30.7% |
| Butter | 0.0% | -2.5% | -2.9% | -3.3% | -3.7% | -4.1% | -2.9% |
| Cheese | 0.9% | 0.1% | 0.5% | 0.3% | 0.0% | -0.3% | 0.2% |
| WMP | 0.9% | -1.2% | -1.1% | -1.4% | -1.8% | -2.1% | -1.2% |
| SMP | 0.3% | -1.9% | -1.9% | -2.1% | -2.4% | -2.7% | -1.9% |
| Meat | -3.5% | -23.3% | -28.7% | -31.2% | -33.8% | -36.5% | -27.1% |
| Dairy | 0.6% | -1.4% | -1.4% | -1.7% | -2.1% | -2.4% | -1.5% |

Under this scenario, modelling projections show an increase in New Zealand consumer spending for livestock commodities by 2050 (see Table 13). The increase in consumer spending for dairy commodities is predicted to be higher than the predicted increase in consumer spending on meat commodities. Total spending on dairy commodities is predicted to increase by US$5.3 billion by 2050 compared to the baseline, spending on meat commodities is expected to grow by US$1.2 billion by 2050.

**Table 13: *Scenario 3* -New Zealand consumer spending (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -16 | 60 | 117 | 143 | 163 | 181 | 648 |
| Sheepmeat | -3 | 54 | 86 | 101 | 114 | 126 | 479 |
| Butter | 36 | 85 | 121 | 127 | 131 | 133 | 634 |
| Cheese | 93 | 210 | 312 | 339 | 359 | 375 | 1,689 |
| WMP | 4 | 9 | 12 | 13 | 14 | 15 | 67 |
| SMP | 146 | 355 | 531 | 589 | 637 | 679 | 2,936 |
| Meat | -18 | 127 | 224 | 267 | 302 | 331 | 1,233 |
| Dairy | 280 | 659 | 977 | 1,069 | 1,140 | 1,202 | 5,327 |

As a result of the predicted decrease in meat and dairy production, NZ GHG emissions from the two livestock types are expected to drop significantly by 2050 as shown in Figure 14. The projected decrease in livestock emissions under this scenario is significantly higher than reductions projected in Scenario 2 where the high government assistance with emissions pricing allowed growth in dairy production. Also, under this scenario by 2050 NZ livestock GHG emissions are projected to be below 2020 emissions levels.

**Figure 14: *Scenario 3* -New Zealand emissions for dairy & red meat**

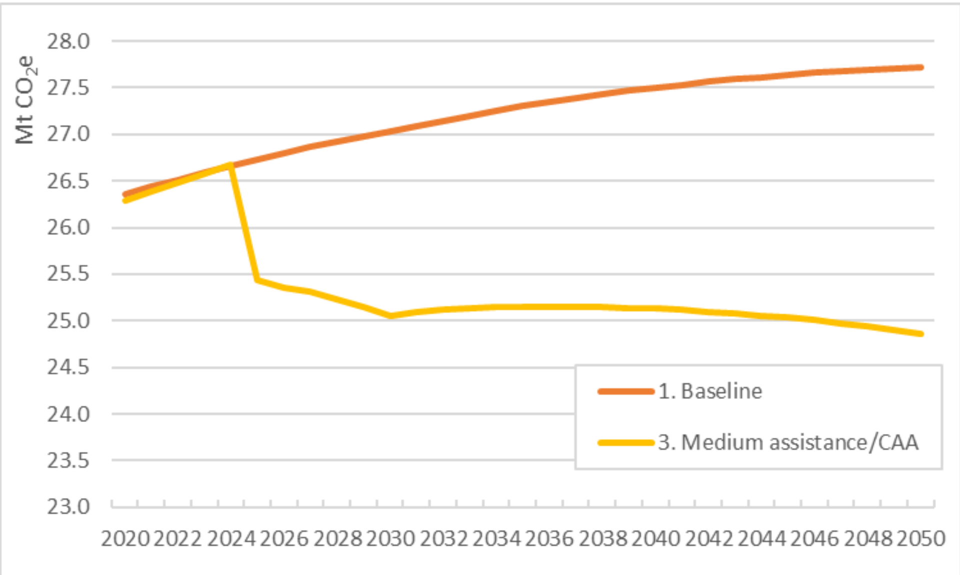
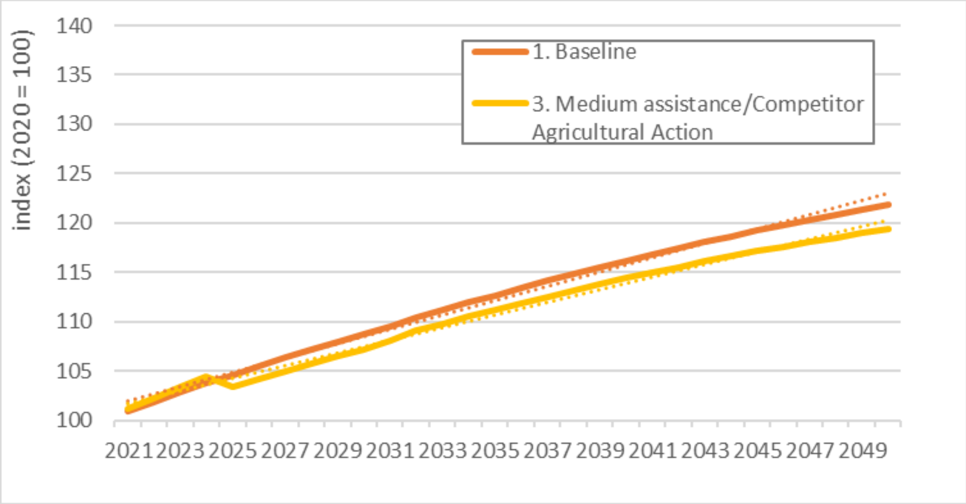



Figure 15 shows NZ dairy price projections between 2021 and 2050. Unlike Scenario 2, it can be seen that dairy prices are slightly lower than those projected in the baseline scenario.

Figure 15: *Scenario 3* -New Zealand producer price for dairy




NB: emissions-price embodied

Figure 16shows modelling results with regards to the deferral of global meat production in 2050 for the two meat commodities. Overall, and as described earlier, global sheepmeat and beef production are expected to decrease by 2050. This is predominately expected for the EU-27, New Zealand, and Brazil whose predicted production falls are due to their high level of climate action assumed under this scenario. Here, China, India, Australia and the United States are the main countries supplanting lost global meat production. In particular, China is expected to become a greater producer of sheepmeat and beef while the United States is expected to produce more beef.

Figure 16: *Scenario 3* -Deferral of global meat production in 2050

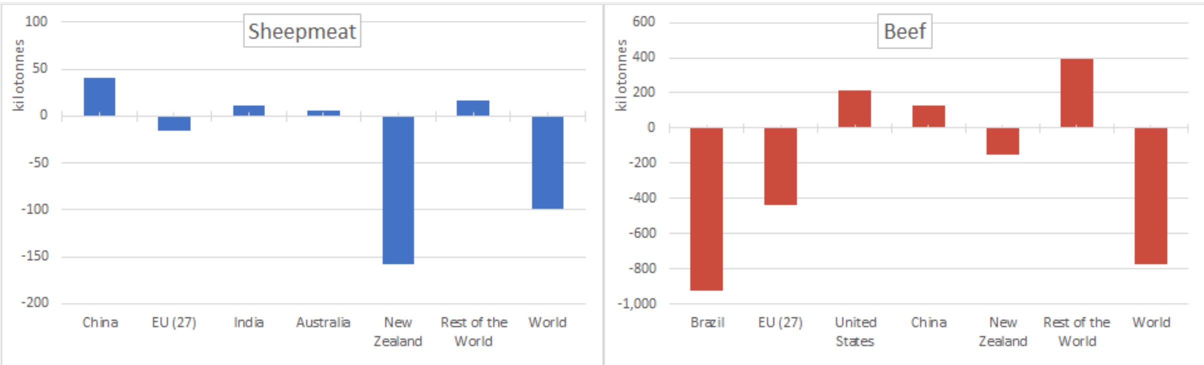



Figure 17 shows the deferral of global dairy production in 2050 for the four examined dairy commodities. As described earlier, global production of all dairy commodities is expected to decrease under this scenario, with projections showing the most significant decrease for global cheese production by 2050. The largest drop in dairy production is projected for Brazil and the EU-27 by 2050; this is due to the global climate action assumed in this scenario. The main countries supplanting lost global dairy production are India, the United States, China and Argentina. In particular, the United States is predicted to become a greater producer of cheese and butter by 2050. Both China and Argentina are projected to increase their production of whole milk powder, while India is expected to increase butter production significantly by 2050.

**Figure 17:** ***Scenario 3*** **-Deferral of global dairy production in 2050**

# 7 Scenario 4: No Assistance/Competitor Agricultural Action

**Table 14:** ***Scenario 4*** **assumptions**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 4 | No assistance/CAA | high | none | As HWEN |

This scenario (Table 14) assumed no assistance for NZ producers when the emissions price is implemented in 2025. In addition, under this scenario the level of global climate action is high. It is assumed that Brazil, EU-27, the UK and Australia fully achieve their agricultural climate commitments.

Model projections for world production by commodity between 2021 and 2050 are presented in Table 15. Results show a significant decrease in global production for all examined commodities due to high global climate action, similar to scenarios 2 and 3, which has a significant impact on the reduction of livestock production.  The largest fall in global livestock production by 2050 is projected for beef (- 14.7 million tonnes), followed by cheese (- 7.3 million tonnes), then sheepmeat (- 3.7 million tonnes).

**Table 15:** ***Scenario 4*** **-World Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | 446 | -1,400 | -2,757 | -3,273 | -3,692 | -4,039 | -14,716 |
| Sheepmeat | -89 | -604 | -719 | -740 | -761 | -781 | -3,694 |
| Butter | -75 | -191 | -266 | -278 | -286 | -292 | -1,388 |
| Cheese | -450 | -968 | -1,387 | -1,466 | -1,516 | -1,554 | -7,340 |
| WMP | -191 | -427 | -595 | -631 | -659 | -685 | -3,190 |
| SMP | -58 | -152 | -213 | -224 | -232 | -238 | -1,116 |
| Meat | 141 | -2,025 | -3,439 | -3,944 | -4,363 | -4,722 | -18,352 |
| Dairy | -773 | -1,738 | -2,461 | -2,599 | -2,693 | -2,769 | -13,034 |

Alongside the global decrease in meat production, NZ is facing the highest burden of emissions pricing with no assistance. Thus, as shown in Table 16, modelling results for NZ show that domestic meat production is expected to drop significantly by 12.3 million tonnes between 2021 and 2050, with an expected drop of beef and sheepmeat production by 6.5 million tonnes and 6.1 million tonnes, respectively. Similarly, dairy production is expected to decrease under this scenario with the largest fall projected for domestic WMP production (-738 kilo tonnes), followed by butter production (-531 kilo tonnes) by 2050.

**Table 16:** ***Scenario 4*** **-New Zealand Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -116 | -1,007 | -1,343 | -1,347 | -1,351 | -1,360 | -6,524 |
| Sheepmeat | -110 | -991 | -1,220 | -1,247 | -1,275 | -1,302 | -6,145 |
| Butter | -6 | -89 | -111 | -109 | -108 | -108 | -531 |
| Cheese | 2 | -26 | -32 | -31 | -30 | -30 | -147 |
| WMP | 2 | -129 | -159 | -154 | -150 | -148 | -738 |
| SMP | -3 | -63 | -77 | -75 | -73 | -72 | -363 |
| Meat | -217 | -1,932 | -2,484 | -2,518 | -2,552 | -2,590 | -12,294 |
| Dairy | -5 | -306 | -378 | -369 | -362 | -358 | -1,779 |

The decrease in domestic producer prices and production leads to a fall in New Zealand producer returns for the two meat commodities. As shown in Table 17, producer returns for meat are projected to drop significantly by 2050. Returns from beef are projected to decrease by 47 per cent while returns from sheepmeat are expected to fall by 40 per cent by 2050. Returns from dairy commodities are projected to drop slightly by 4.6 per cent by 2050 with the largest decrease expected for butter (-5.7 per cent) then SMP (-4.9 per cent).

**Table 17:** ***Scenario 4*** **-New Zealand producer returns (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -7,175 | -47,991 | -58,359 | -60,525 | -62,393 | -64,066 | -300,510 |
| Sheepmeat | -8,189 | -60,073 | -72,606 | -76,255 | -79,371 | -81,977 | -378,472 |
| Butter | -998 | -10,950 | -13,212 | -13,477 | -13,751 | -14,027 | -66,416 |
| Cheese | 281 | -3,473 | -3,727 | -3,612 | -3,567 | -3,556 | -17,654 |
| WMP | 70 | -19,081 | -21,889 | -21,853 | -21,904 | -21,953 | -106,610 |
| SMP | -630 | -10,012 | -11,590 | -11,651 | -11,753 | -11,871 | -57,505 |
| Meat | -15,175 | -106,628 | -129,237 | -135,127 | -140,170 | -144,498 | -670,835 |
| Dairy | -1,277 | -43,516 | -50,418 | -50,593 | -50,975 | -51,406 | -248,184 |
| % change from base scenario | | | | | | | |
| Beef | -7.6% | -47.9% | -55.2% | -54.8% | -54.4% | -54.1% | -46.7% |
| Sheepmeat | -5.9% | -40.6% | -46.5% | -46.6% | -46.7% | -46.9% | -39.7% |
| Butter | -0.6% | -6.0% | -6.9% | -6.7% | -6.6% | -6.5% | -5.7% |
| Cheese | 0.2% | -3.0% | -3.1% | -2.9% | -2.8% | -2.8% | -2.4% |
| WMP | 0.0% | -5.4% | -5.9% | -5.6% | -5.4% | -5.2% | -4.7% |
| SMP | -0.4% | -5.6% | -6.1% | -5.8% | -5.5% | -5.3% | -4.9% |
| Meat | -5.8% | -38.9% | -44.9% | -45.0% | -45.2% | -45.4% | -38.3% |
| Dairy | -0.2% | -5.2% | -5.7% | -5.5% | -5.3% | -5.2% | -4.6% |

Under this scenario, modelling projections show an increase in New Zealand consumer spending for livestock commodities by 2050 (see Table 18). The increase in consumer spending for dairy commodities is predicted to be higher than the predicted increase in consumer spending for meat commodities. Spending on dairy commodities is predicted to increase by US$5.8 billion by 2050 compared to the baseline, spending on meat commodities is expected to grow by US$1.7 million USD by 2050.

**Table 18: *Scenario 4* -New Zealand consumer spending (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -13 | 95 | 160 | 182 | 200 | 214 | 838 |
| Sheepmeat | 3 | 109 | 152 | 163 | 171 | 177 | 774 |
| Butter | 37 | 97 | 136 | 141 | 143 | 144 | 698 |
| Cheese | 94 | 214 | 317 | 344 | 363 | 379 | 1,709 |
| WMP | 4 | 10 | 13 | 14 | 15 | 16 | 73 |
| SMP | 153 | 419 | 615 | 667 | 709 | 745 | 3,309 |
| Meat | -9 | 219 | 335 | 370 | 396 | 417 | 1,728 |
| Dairy | 288 | 740 | 1,082 | 1,166 | 1,230 | 1,283 | 5,789 |

As a result of the predicted decreases in meat and dairy production associated with the emissions price and the high level of global climate action of competitor countries, NZ GHG emissions from the two livestock types are expected to drop significantly by 2050 as shown in Figure 18. The projected reduction in livestock emissions under this scenario is the greatest of the three global action scenarios, with no government assistance assumed. Under this scenario emissions drop strongly in 2025 as the emissions price is introduced, before decreasing gradually until 2030 as the emissions price increases. After 2030 however emission rise slightly as the emissions price has stabilised and prices rise.

**Figure 18: *Scenario 4* -New Zealand emissions for dairy & red meat**

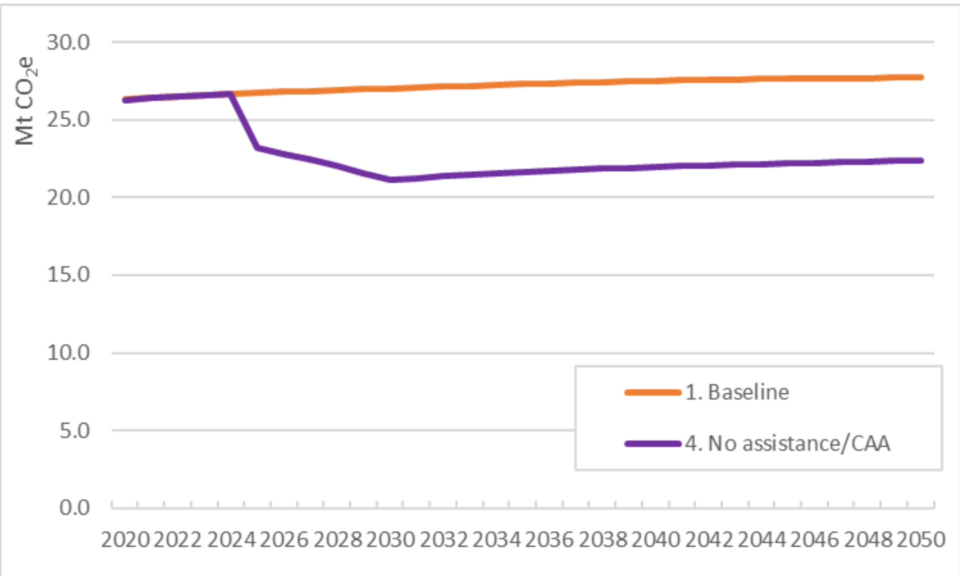
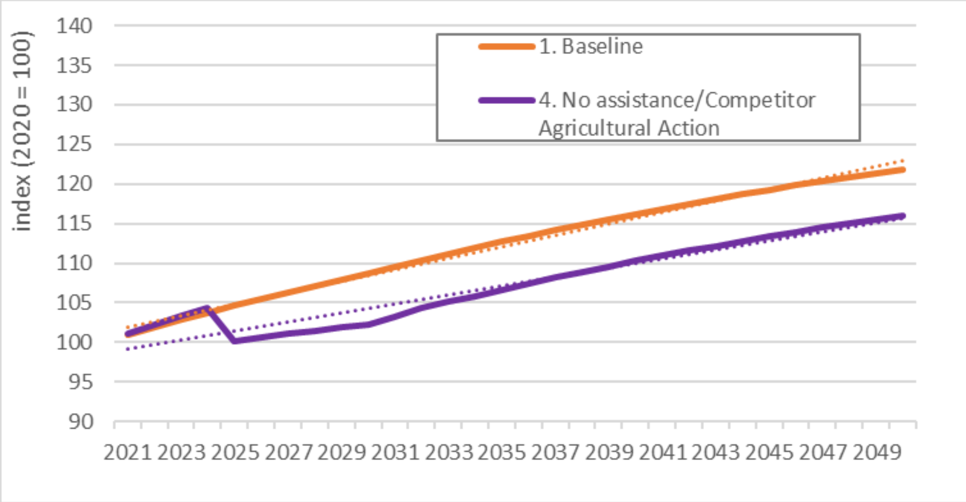



Figure 19 shows projection of the NZ dairy price by 2050. It can be seen that dairy prices drop below baseline levels from 2024 onwards, albeit rising relative to the baseline after 2030.

**Figure 19: *Scenario 4* -New Zealand producer price for dairy**




NB: emissions-price embodied

This scenario implies the highest lost production in New Zealand and its trade competitors. In particular, production losses are projected for the EU-27, Brazil and New Zealand. China and the United States are the main countries supplanting lost global beef production (see Figure 20). In particular, China is projected to become a greater producer of sheepmeat and to a lesser extent of beef commodities, while the United States are projected to become a greater producer of beef by 2050.

**Figure 20: *Scenario 4* -Deferral of global meat production in 2050**

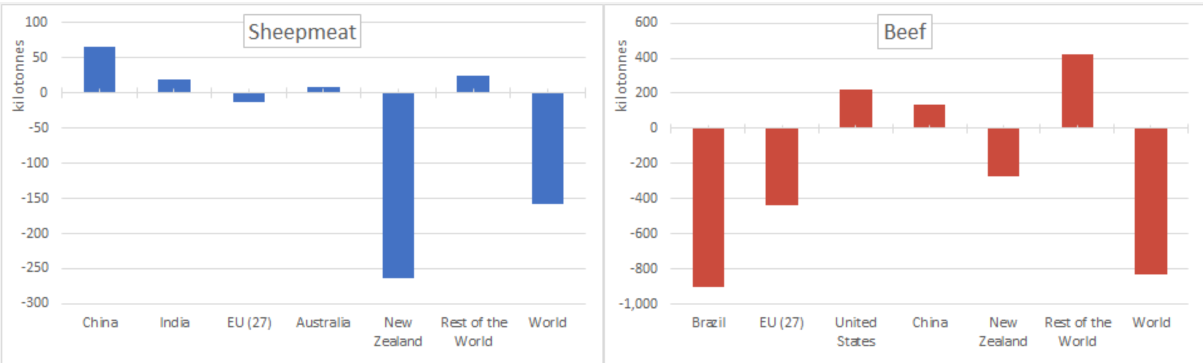



Figure 21 shows the deferral of global dairy production by 2050 for the four examined dairy commodities. As described earlier, global production of all dairy commodities is expected to decrease under this scenario, with projections showing the most significant decrease for global cheese production. In particular, production losses for dairy commodities are projected for the EU-27, Brazil and New Zealand. Here, China, India, the United States and Argentina are the main countries supplanting lost global dairy production. The United States is expected to become a greater producer of cheese and skim milk powder. China is projected to increase its production of whole milk powder while India increases butter production by 2050.

**Figure 21:** ***Scenario 4*** **-Deferral of global dairy production in 2050**

# 8 Scenario 5: High Assistance

**Table 19:** ***Scenario 5*** **assumptions**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 5 | High assistance | none | 95% decreasing 1% yearly | As HWEN |

This scenario (Table 19) assumed high assistance for NZ producers with 95 per cent of the emissions price subsidised by the government from 2025 and a subsequent drop of assistance by 1 per cent annually. Scenario 5 (High Assistance) also assumes that competitor markets have no established climate policy commitments for agricultural production, thus enabling them to make up the shortfall from decreases in New Zealand production of red meat (beef and sheepmeat) and dairy commodities (butter, cheese, WMP and SMP).

Table 20 shows changes in world production of red meat (beef and sheepmeat) and dairy commodities (butter, cheese, WMP and SMP) resulting from this scenario. Modelling results show that global meat production is projected to decrease by 723 kilo tonnes over the projection period. In more detail, reductions in world sheepmeat production are expected (-488 kilo tonnes) and to a slightly lesser extent global beef production is projected to drop by 370 kilo tonnes by 2050. The reduction of meat production is set to increase over time, with relatively greater reductions in world meat production closer to 2050 than the start of this period as government assistance decreases.

Similarly, world dairy production is projected to decrease under this scenario, with total production projected to decrease by 148 kilo tonnes over the projection period. Under this scenario, reductions in world WMP were predicted (-56 kilo tonnes), followed by butter (-37 kilo tonnes total), SMP (-33 kilo tonnes) and cheese (-22 kilo tonnes).

**Table 20:** ***Scenario 5*** **-World Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -2 | -21 | -41 | -71 | -101 | -133 | -370 |
| Sheepmeat | -4 | -30 | -56 | -94 | -132 | -172 | -488 |
| Butter | -0 | -2 | -4 | -7 | -10 | -13 | -37 |
| Cheese | -0 | -1 | -2 | -4 | -6 | -8 | -22 |
| WMP | -0 | -3 | -7 | -11 | -15 | -19 | -56 |
| SMP | -0 | -2 | -4 | -6 | -9 | -11 | -33 |
| Meat | -5 | -42 | -82 | -138 | -197 | -259 | -723 |
| Dairy | -1 | -9 | -17 | -29 | -40 | -52 | -148 |

Table 21 shows changes in NZ production of red meat (beef and sheepmeat) and dairy commodities (butter, cheese, WMP and SMP) resulting from this policy scenario. This shows a reduction in total meat production of 1.6 million tonnes over the period 2021 to 2050, with reductions increasing over time (from 10 kilo tonnes in the period 2021-2025 to 573 kilo tonnes in the period 2046-2050). These reductions are relatively evenly split between sheepmeat (total reduction of 839 kilo tonnes) and beef production (total reduction 799 kilo tonnes), with reductions also increasing over time.

Similarly, New Zealand dairy production is projected to decrease over time in this scenario, with total reductions of 313 kilo tonnes. This comprises reductions in New Zealand WMP production (- 138 kilo tonnes), followed by butter (- 83 kilo tonnes), SMP (- 60 kilo tonnes) and cheese (- 32 kilo tonnes) by 2050.

**Table 21:** ***Scenario 5*** **-New Zealand Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -5 | -46 | -90 | -153 | -219 | -287 | -799 |
| Sheepmeat | -5 | -50 | -96 | -161 | -228 | -299 | -839 |
| Butter | -1 | -5 | -10 | -16 | -23 | -29 | -83 |
| Cheese | -0 | -2 | -4 | -6 | -9 | -11 | -32 |
| WMP | -1 | -9 | -16 | -27 | -37 | -48 | -138 |
| SMP | -0 | -4 | -7 | -12 | -16 | -21 | -60 |
| Meat | -10 | -93 | -181 | -306 | -437 | -573 | -1,600 |
| Dairy | -2 | -19 | -37 | -61 | -85 | -109 | -313 |

Reductions in NZ meat and dairy production associated with the advent of emissions pricing, will also impact NZ producer returns as shown in Table 22. NZ producer returns for meat and dairy are projected to decrease, with these reductions progressively increasing over time. NZ producer returns for meat (beef and sheepmeat) are projected to decrease by 6.4 per cent by 2050 compared to the baseline. Dairy is also projected to experience reductions in returns for NZ producers by 1 per cent. WMP is projected to experience the greatest reduction in returns (-1 per cent), followed by butter and SMP (-0.9 per cent, each). Overall, meat is projected to experience greater reductions in returns relative to dairy, which reflects the relative decrease in production volume.

**Table 22: *Scenario 5* -New Zealand producer returns (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -362 | -2,845 | -5,591 | -9,425 | -13,410 | -17,500 | -49,133 |
| Sheepmeat | -458 | -3,662 | -7,164 | -12,095 | -17,228 | -22,482 | -63,089 |
| Butter | -88 | -637 | -1,238 | -2,077 | -2,954 | -3,865 | -10,859 |
| Cheese | -40 | -293 | -564 | -938 | -1,325 | -1,723 | -4,883 |
| WMP | -187 | -1,343 | -2,602 | -4,355 | -6,186 | -8,082 | -22,755 |
| SMP | -89 | -633 | -1,231 | -2,068 | -2,945 | -3,859 | -10,825 |
| Meat | -813 | -6,454 | -12,657 | -21,363 | -30,424 | -39,711 | -111,422 |
| Dairy | -405 | -2,905 | -5,635 | -9,438 | -13,411 | -17,528 | -49,321 |
| % change from base scenario | | | | | | | |
| Beef | -0.4% | -2.8% | -5.3% | -8.5% | -11.7% | -14.8% | -7.6% |
| Sheepmeat | -0.3% | -2.5% | -4.6% | -7.4% | -10.1% | -12.9% | -6.6% |
| Butter | -0.1% | -0.3% | -0.6% | -1.0% | -1.4% | -1.8% | -0.9% |
| Cheese | 0.0% | -0.3% | -0.5% | -0.8% | -1.0% | -1.3% | -0.7% |
| WMP | -0.1% | -0.4% | -0.7% | -1.1% | -1.5% | -1.9% | -1.0% |
| SMP | -0.1% | -0.4% | -0.6% | -1.0% | -1.4% | -1.7% | -0.9% |
| Meat | -0.3% | -2.4% | -4.4% | -7.1% | -9.8% | -12.5% | -6.4% |
| Dairy | -0.1% | -0.3% | -0.6% | -1.0% | -1.4% | -1.8% | -0.9% |

Table 23 shows impacts on NZ consumer spending on meat and dairy under this scenario. NZ consumer spending on meat is projected to increase by 2050 (+ US$124 million) alongside spending on dairy ($US113 million). Across all commodities, largest increase in NZ consumer spending is projected for SMP (+US$90 million) and sheepmeat products (+US$75 million) by 2050.

**Table 23: *Scenario 5* -New Zealand consumer spending (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | 0 | 3 | 5 | 9 | 13 | 17 | 47 |
| Sheepmeat | 0 | 5 | 9 | 14 | 20 | 27 | 75 |
| Butter | 0 | 1 | 2 | 3 | 4 | 5 | 15 |
| Cheese | 0 | 0 | 1 | 1 | 2 | 2 | 6 |
| WMP | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| SMP | 1 | 5 | 10 | 17 | 25 | 32 | 90 |
| Meat | 1 | 7 | 14 | 24 | 34 | 44 | 124 |
| Dairy | 1 | 7 | 13 | 22 | 31 | 40 | 113 |

Figure 22 shows projected changes in NZ GHG emissions for red meat and dairy production compared to the baseline. NZ GHG emissions are projected to decrease in 2025 with the introduction of the emissions price, and then are projected gradually to increase until 2033, before declining until 2050, ultimately equating to slightly higher than 2020 emissions in the year 2050. This reflects the increasing burden of emission prices as the government assistance is removed year on year.

**Figure 22:** ***Scenario 5*** **-New Zealand emissions for dairy & red meat**

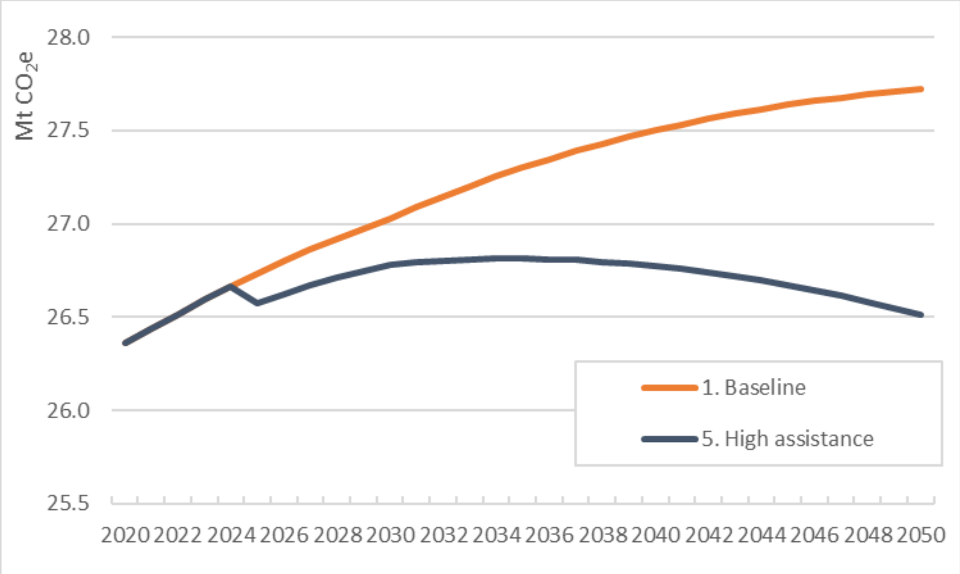
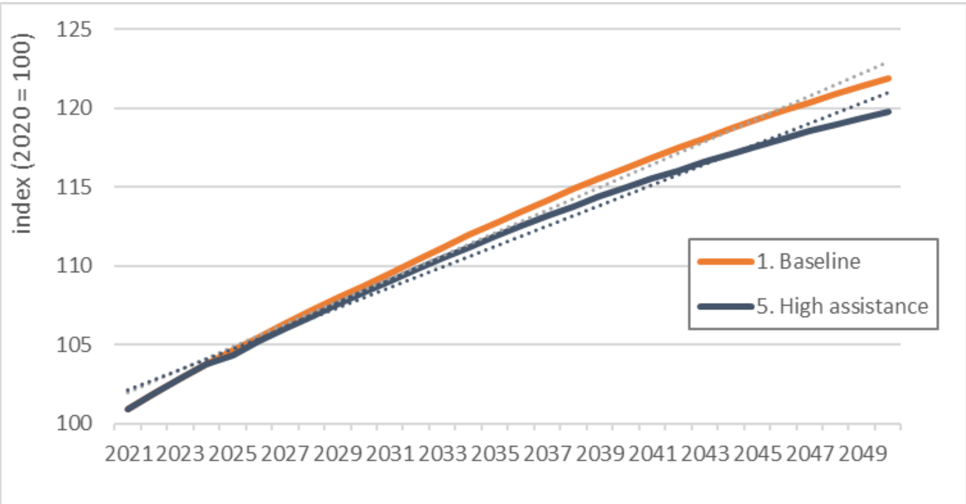



Figure 23 shows projected changes for a weighted average NZ producer price for dairy, including the embodied emissions price. This shows a slight decrease from the baseline over time, with the NZ producer price index for dairy projected to be valued at approximately 120 relative to the baseline (approximately 122). This shows that, in this scenario, the dairy price is still expected to rise, but unlike Scenario 2, with no global action, NZ producer prices are expected to decrease compared to the baseline scenario.

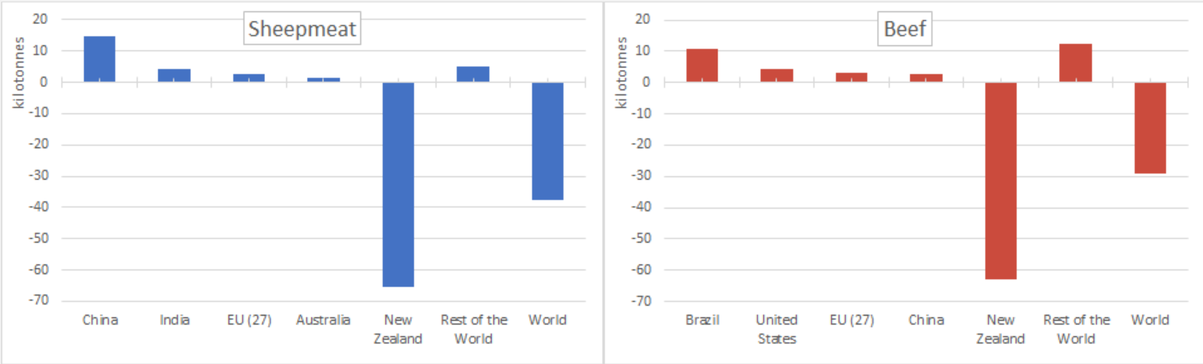
**Figure 23:** ***Scenario 5*** **-New Zealand producer price for dairy**




NB: emissions-price embodied

With the declining production volumes for meat and dairy predicted in this Scenario, NZ's export competitors are expected to capture the opportunity to fill this shortfall on the global market. As such, Figure 24 shows the various impacts on the deferral of global meat production in 2050. For sheepmeat, global and domestic production is projected to decrease, leaving a gap in the global market for sheepmeat supply. In response to this shortfall, China, India, EU-27 and Australia are all expected to increase production relative to the baseline. For beef, Brazil, the United States, EU-27 and China are projected to become a greater producers by 2050.

**Figure 24:** ***Scenario 5*** **-Deferral of global meat production in 2050**




Similarly, Figure 25 shows the various impacts on the deferral of global dairy commodity production (including butter, cheese, SMP and WMP) in 2050. For all dairy commodities modelled, domestic and global production is projected to decrease, leaving a gap in the global market for each commodity. However, it should be noted that for each commodity examined, the deferral of world dairy production is still not sufficient to replace New Zealand's deficit completely. The main countries supplanting lost global dairy production are India, EU-27, Australia, Brazil, Japan, the United States and China. In particular, India is projected to become a greater exporter of butter in 2050 while Argentina is projected to export more cheese in 2050. In addition, China is projected to increase their production of WMP while the United States is expected to increase SMP production by 2050.

**Figure 25:** ***Scenario 5*** **-Deferral of global dairy production in 2050**

# 9 Scenario 6: Medium Assistance

**Table 24: *Scenario 6* assumptions**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 6 | Med assistance | none | 60% decreasing 1% yearly | As HWEN |

This scenario (Table 24) assumed medium assistance for NZ producers with 60 per cent of the emissions price subsidised by the government from 2025 onwards with a subsequent drop of assistance by 1 per cent annually. In addition, no climate policy action from competitor countries was assumed in this scenario.

Table 25 shows changes in world production of red meat (beef and sheepmeat) and dairy commodities (butter, cheese, WMP and SMP) resulting from this scenario. This shows that total world meat production is projected to decrease by 2.6 million tonnes between 2021 and 2050. Large reductions in world sheepmeat production are projected (- 1.7 million tonnes) as well as reductions in global beef production (-1.4 million tonnes). The reduction of meat production is set to increase over time, with relatively greater reductions in world meat production closer to 2050 than at the start of this period as government assistance with emissions pricing decreases.

Similarly, world dairy production is projected to decrease under this scenario, with total production projected to decrease by 546 kilo tonnes by 2050. Under this scenario, relatively larger reductions in global WMP production were projected (-208 kilo tonnes), followed by butter (-136 kilo tonnes), SMP (-122 kilo tonnes) and cheese (-81 kilo tonnes).

**Table 25: *Scenario 6* -World Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -18 | -175 | -247 | -281 | -316 | -353 | -1,390 |
| Sheepmeat | -32 | -236 | -301 | -342 | -386 | -431 | -1,728 |
| Butter | -3 | -18 | -24 | -27 | -30 | -33 | -136 |
| Cheese | -1 | -10 | -15 | -17 | -19 | -21 | -81 |
| WMP | -3 | -28 | -38 | -42 | -46 | -50 | -208 |
| SMP | -2 | -17 | -22 | -24 | -27 | -29 | -122 |
| Meat | -43 | -343 | -456 | -521 | -590 | -663 | -2,616 |
| Dairy | -9 | -73 | -99 | -110 | -122 | -134 | -546 |

Table 26 shows changes in New Zealand production of red meat (beef and sheepmeat) and dairy commodities (butter, cheese, WMP and SMP) resulting from this scenario. This shows a reduction in total meat production of 5.9 million tonnes between 2021 and 2050, with reductions increasing over time (from 79 kilo tonnes in the period 2021-2025 to 1.5 million tonnes in the period 2046-2050). These reductions are relatively evenly split between sheepmeat (-3 million tonnes) and beef production (- 3 million tonnes) by 2050.

Similarly, NZ dairy production is projected to decrease over time in this scenario, with total reductions of 1.2 million tonnes of total dairy production by 2050. This comprises reductions in New Zealand WMP production (- 511 kilo tonnes), followed by butter (- 306 kilo tonnes), SMP (-223 kilo tonnes) and cheese (- 120 kilo tonnes) between 2021 and 2050.

**Table 26: *Scenario 6* -New Zealand Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -39 | -379 | -539 | -613 | -689 | -768 | -3,027 |
| Sheepmeat | -44 | -399 | -526 | -600 | -676 | -756 | -3,000 |
| Butter | -5 | -41 | -55 | -62 | -68 | -75 | -306 |
| Cheese | -2 | -16 | -22 | -24 | -27 | -30 | -120 |
| WMP | -9 | -69 | -92 | -103 | -114 | -125 | -511 |
| SMP | -4 | -30 | -40 | -45 | -49 | -54 | -223 |
| Meat | -79 | -757 | -1,037 | -1,182 | -1,332 | -1,487 | -5,874 |
| Dairy | -19 | -157 | -209 | -233 | -258 | -284 | -1,160 |

Reductions in NZ meat and dairy production will also impact NZ producer returns as shown in Table 27. Modelling results show that NZ producer returns for both meat and dairy are projected to decrease, with these reductions progressively increasing over time. NZ producer returns for meat production (beef and sheepmeat) are projected to decrease by 21.2 per cent by 2050 compared to the baseline. NZ producer returns for dairy commodities are also projected to decrease by 2050. Overall, returns from dairy are expected to fall by 3.3 per cent by 2050 with the largest fall projected for returns from WPM (-3.5 per cent), then butter and SMP (-.3.3 per cent, each) by 2050. Overall, meat is projected to experience greater reductions in returns relative to dairy, which reflects the relative decrease in production volume.

**Table 27: *Scenario 6* -New Zealand producer returns (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -2,826 | -21,571 | -28,882 | -33,141 | -37,401 | -41,667 | -165,488 |
| Sheepmeat | -3,534 | -27,360 | -35,980 | -41,564 | -47,135 | -52,618 | -208,191 |
| Butter | -699 | -5,068 | -6,699 | -7,695 | -8,713 | -9,753 | -38,627 |
| Cheese | -323 | -2,336 | -3,062 | -3,489 | -3,921 | -4,359 | -17,490 |
| WMP | -1,493 | -10,691 | -14,041 | -16,106 | -18,217 | -20,370 | -80,918 |
| SMP | -708 | -5,040 | -6,631 | -7,638 | -8,670 | -9,725 | -38,413 |
| Meat | -6,296 | -48,465 | -64,272 | -74,058 | -83,831 | -93,521 | -370,443 |
| Dairy | -3,223 | -23,135 | -30,433 | -34,928 | -39,520 | -44,208 | -175,447 |
| % change from base scenario | | | | | | | |
| Beef | -3.0% | -21.5% | -27.3% | -30.0% | -32.6% | -35.2% | -25.7% |
| Sheepmeat | -2.5% | -18.5% | -23.0% | -25.4% | -27.7% | -30.1% | -21.9% |
| Butter | -0.4% | -2.8% | -3.5% | -3.8% | -4.2% | -4.6% | -3.3% |
| Cheese | -0.3% | -2.0% | -2.6% | -2.8% | -3.1% | -3.4% | -2.4% |
| WMP | -0.4% | -3.0% | -3.8% | -4.1% | -4.5% | -4.8% | -3.5% |
| SMP | -0.4% | -2.8% | -3.5% | -3.8% | -4.1% | -4.4% | -3.3% |
| Meat | -2.4% | -17.7% | -22.3% | -24.7% | -27.0% | -29.4% | -21.2% |
| Dairy | -0.4% | -2.7% | -3.4% | -3.8% | -4.1% | -4.5% | -3.3% |

Table 28 shows impacts on New Zealand consumer spending on meat and dairy over the projection period. Across all commodities, NZ consumer spending on meat and dairy is expected to increase over time. Modelling results project and increase of US$451 million spending on meat products and US$418 million on dairy products between 2021 and 2050.

**Table 28: *Scenario 6* -New Zealand consumer spending (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | 2 | 22 | 30 | 34 | 39 | 43 | 170 |
| Sheepmeat | 4 | 36 | 48 | 55 | 61 | 68 | 272 |
| Butter | 1 | 8 | 11 | 12 | 13 | 14 | 58 |
| Cheese | 0 | 3 | 4 | 5 | 5 | 6 | 23 |
| WMP | 0 | 1 | 1 | 1 | 1 | 1 | 5 |
| SMP | 5 | 42 | 59 | 67 | 75 | 84 | 332 |
| Meat | 6 | 59 | 80 | 91 | 102 | 113 | 451 |
| Dairy | 6 | 53 | 74 | 84 | 95 | 105 | 418 |

Figure 26 shows projected changes in NZ GHG emissions for red meat and dairy production compared to the baseline scenario. Results show that GHG emissions decrease in 2025 with the introduction of the emissions price, and then are projected to gradually decrease over the modelled period, ultimately equating to approximately just under 25 $MtCO_2e$ in the year 2050.

**Figure 26:** ***Scenario 6*** **-New Zealand emissions for dairy & red meat**

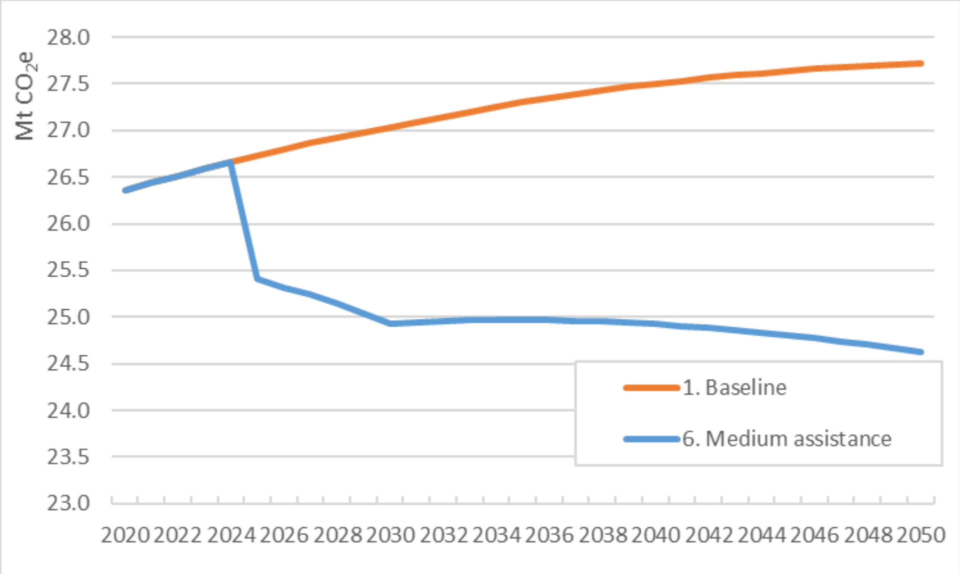
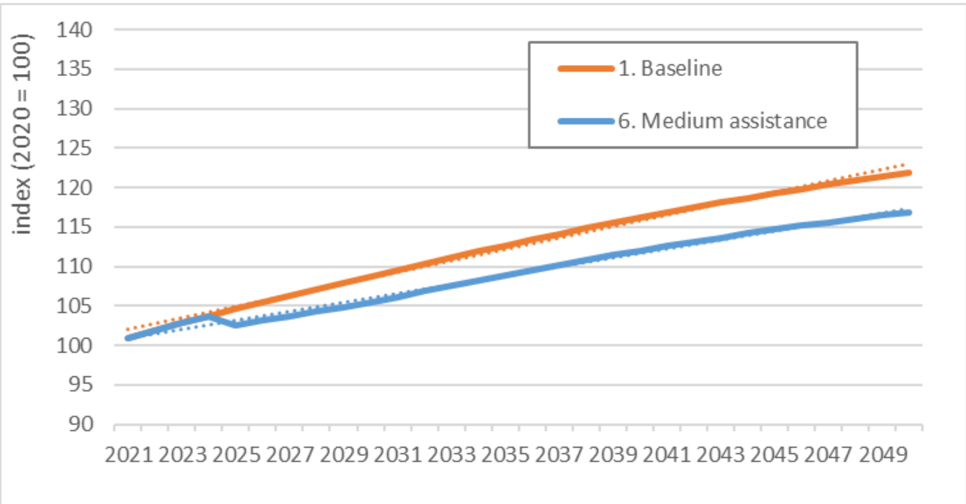



Figure 27 shows the projected changes for a weighted average NZ producer price for dairy. This shows a slight decrease from the baseline over time, with the NZ producer price index for dairy projected to be valued at approximately 117 relative to the baseline (approximately 122). This shows that, in this scenario, the dairy price is still expected to rise, but remain lower than in the baseline.

**Figure 27:** ***Scenario 6*** **-New Zealand producer price for dairy**




NB: emissions-price embodied

With the declining production volumes for meat and dairy shown in this scenario, it is likely that NZ competitor countries could capture the opportunity to fill this shortfall on the global market. Figure 28 shows the various impacts on the deferral of global meat production for sheepmeat and beef in 2050. The main countries supplanting lost global meat production areChina, India, the United States, Brazil, EU-27 and Australia that are projected to become greater exporters of red meat commodities by 2050.

**Figure 28:** ***Scenario 6*** **-Deferral of global meat production in 2050**

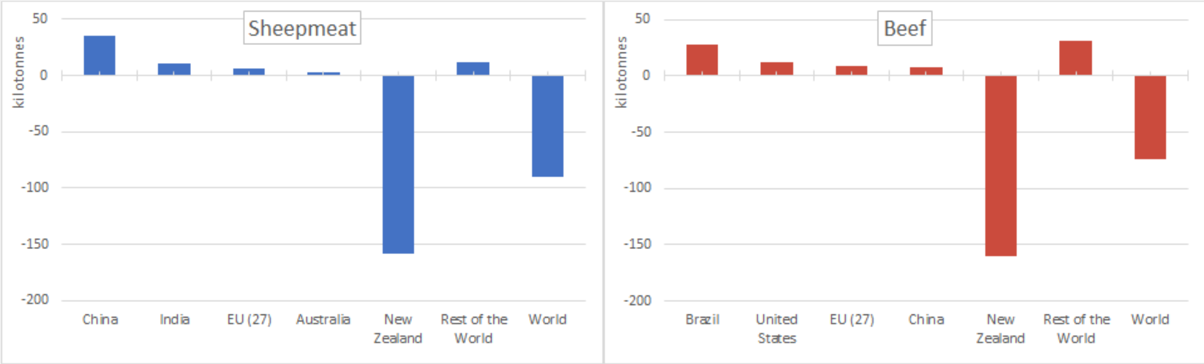



Figure 29 shows the various impacts on the deferral of global dairy commodity production (including butter, cheese, SMP and WMP) in 2050. For all dairy commodities modelled, NZ production is projected to decrease, leaving a gap in the global market for each commodity. However, it should be noted that for each commodity examined, with New Zealand's production deficit in each dairy commodity, the deferral of world dairy production is still not sufficient to replace New Zealand's decreased production completely.

The main countries supplanting lost global dairy production are India, EU-27, Australia, Brazil, Japan, the United States and China. In particular, India is projected to become a greater exporter of butter in 2050 while Argentina is projected to export more cheese in 2050. In addition, China is projected to increase their production of WMP while the United States is expected to increase SMP production by 2050.

**Figure 29:** ***Scenario 6*** **-Deferral of global dairy production in 2050**

# 10 Scenario 7: No Assistance

**Table 29:** ***Scenario 7*** **assumptions**

| # | Scenario name | Global action | Rate of assistance | Emissions price |
|---|---|---|---|---|
| 7 | No assistance | none | none | As HWEN |

This scenario (Table 29) assumed no assistance for NZ producers with emissions pricing implemented in 2030. Also, under this scenario, there is no global climate action from any other countries. Although this scenario is unlikely to occur it provides a good insight into the impact of NZ climate policy on global and domestic livestock production and GHG emissions from livestock

Table 30 shows model projections on world production by commodity over the projection period 2021-2050. Results show a slight decrease in global production for all examined commodities due to decreases in New Zealand production associated with the introduction of emissions pricing for livestock emissions, with larger decreases projected for meat production and to a lesser extent to dairy production. The largest production drop is projected for sheepmeat (-3.5 million tonnes), followed by beef (- 3 million tonnes), then WMP (-447 kilo tonnes) by 2050.

**Table 30:** ***Scenario 7*** **-World Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -49 | -469 | -625 | -631 | -638 | -647 | -3,059 |
| Sheepmeat | -81 | -584 | -691 | -706 | -721 | -737 | -3,519 |
| Butter | -7 | -46 | -58 | -58 | -59 | -59 | -288 |
| Cheese | -2 | -25 | -35 | -36 | -36 | -36 | -169 |
| WMP | -9 | -72 | -93 | -92 | -91 | -91 | -447 |
| SMP | -6 | -43 | -54 | -53 | -53 | -52 | -260 |
| Meat | -111 | -873 | -1,090 | -1,113 | -1,138 | -1,166 | -5,491 |
| Dairy | -23 | -186 | -240 | -239 | -238 | -238 | -1,164 |

For New Zealand, modelling results predicted meat and dairy production to decrease significantly by 2050 as shown in Table 31. In particular beef production is predicated to fall by 6,738 kilo tonnes by 2050, followed by sheepmeat production which is expected to fall by 6.1 million tonnes by 2050. Also, domestic dairy production is expected to fall by 2050 with largest drops projected for WMP (-1 million tonnes), then butter (-655 kilo tonnes). NZ production losses predicted in this scenario are the highest compared to the other scenarios. This result is expected as NZ is the only country that has climate action in place in this scenario, with no government assistance.

**Table 31: *Scenario 7* -New Zealand Production (000 tonnes)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -105 | -1,021 | -1,383 | -1,397 | -1,408 | -1,424 | -6,738 |
| Sheepmeat | -112 | -991 | -1,219 | -1,246 | -1,273 | -1,301 | -6,142 |
| Butter | -13 | -104 | -134 | -134 | -135 | -135 | -655 |
| Cheese | -5 | -41 | -53 | -53 | -53 | -53 | -258 |
| WMP | -21 | -176 | -227 | -226 | -225 | -225 | -1,101 |
| SMP | -10 | -78 | -99 | -98 | -97 | -97 | -478 |
| Meat | -208 | -1,946 | -2,521 | -2,565 | -2,605 | -2,649 | -12,496 |
| Dairy | -48 | -399 | -513 | -512 | -510 | -510 | -2,493 |

The impact of the emissions price with no government assistance and the subsequent drop in production leads to decreased NZ producer returns from meat and dairy commodities. Modelling results (Table 32) show significant drops in beef and sheepmeat returns which are predicted to fall by 47 per cent and 40 per cent, respectively by 2050. Dairy returns are predicted to fall by 7 per cent by 2050 with the highest decrease predicted for WMP returns (-7.3 per cent), then butter (-6.8 per cent).

**Table 32: *Scenario 7* -New Zealand producer returns (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | -6,722 | -48,460 | -59,442 | -61,934 | -64,059 | -65,939 | -306,555 |
| Sheepmeat | -8,250 | -60,139 | -72,671 | -76,343 | -79,480 | -82,100 | -378,983 |
| Butter | -1,728 | -12,565 | -15,610 | -16,075 | -16,483 | -16,861 | -79,323 |
| Cheese | -800 | -5,820 | -7,177 | -7,325 | -7,449 | -7,564 | -36,135 |
| WMP | -3,699 | -26,515 | -32,625 | -33,558 | -34,384 | -35,145 | -165,926 |
| SMP | -1,756 | -12,504 | -15,399 | -15,907 | -16,361 | -16,776 | -78,704 |
| Meat | -14,788 | -107,166 | -130,378 | -136,615 | -141,935 | -146,482 | -677,365 |
| Dairy | -7,984 | -57,403 | -70,812 | -72,865 | -74,677 | -76,346 | -360,088 |
| % change from base scenario | | | | | | | |
| Beef | -7.1% | -48.3% | -56.3% | -56.0% | -55.8% | -55.7% | -47.6% |
| Sheepmeat | -5.9% | -40.6% | -46.5% | -46.6% | -46.8% | -46.9% | -39.8% |
| Butter | -1.0% | -6.8% | -8.1% | -8.0% | -7.9% | -7.9% | -6.8% |
| Cheese | -0.7% | -5.0% | -6.0% | -5.9% | -5.9% | -5.9% | -5.0% |
| WMP | -1.1% | -7.5% | -8.7% | -8.6% | -8.5% | -8.4% | -7.3% |
| SMP | -1.1% | -7.0% | -8.1% | -7.9% | -7.7% | -7.6% | -6.7% |
| Meat | -5.7% | -39.1% | -45.3% | -45.5% | -45.8% | -46.0% | -38.7% |
| Dairy | -1.0% | -6.8% | -8.0% | -7.9% | -7.8% | -7.7% | -6.7% |

Under this scenario, modelling projections show a slight increase in New Zealand consumer spending for livestock commodities by 2050 (see Table 33). The increase in consumer spending for meat commodities is predicted to be higher than the predicted increase in consumer spending for dairy commodities. Spending on meat commodities is predicted to increase by US$939 million over the projection period, spending on dairy commodities is expected to grow by US$892 million.

Table 33: ***Scenario 7*** **-New Zealand consumer spending (million USD)**

| Commodity | 2021-2025 | 2026-2030 | 2031-2035 | 2036-2040 | 2041-2045 | 2046-2050 | Total |
|---|---|---|---|---|---|---|---|
| Beef | 6 | 56 | 71 | 73 | 75 | 76 | 356 |
| Sheepmeat | 9 | 91 | 113 | 115 | 117 | 118 | 563 |
| Butter | 2 | 20 | 26 | 26 | 25 | 25 | 124 |
| Cheese | 0 | 7 | 10 | 10 | 10 | 11 | 48 |
| WMP | 0 | 2 | 2 | 2 | 2 | 2 | 10 |
| SMP | 12 | 108 | 143 | 146 | 149 | 151 | 709 |
| Meat | 15 | 150 | 189 | 192 | 195 | 198 | 939 |
| Dairy | 14 | 136 | 181 | 185 | 187 | 189 | 892 |

As a result of the predicted fall in NZ meat and dairy production, NZ GHG emissions from the two livestock types are expected to decrease over time as shown in Figure 30. This shows that NZ climate policies assumed under this scenario are successful in reducing livestock emissions. Compared to the previous scenarios, this scenario has the largest decrease in NZ GHG emissions from livestock production; and by 2050 NZ GHG emissions are projected to be below 2020 emissions levels.

**Figure 30:** ***Scenario 7*** **-New Zealand emissions for dairy & red meat**

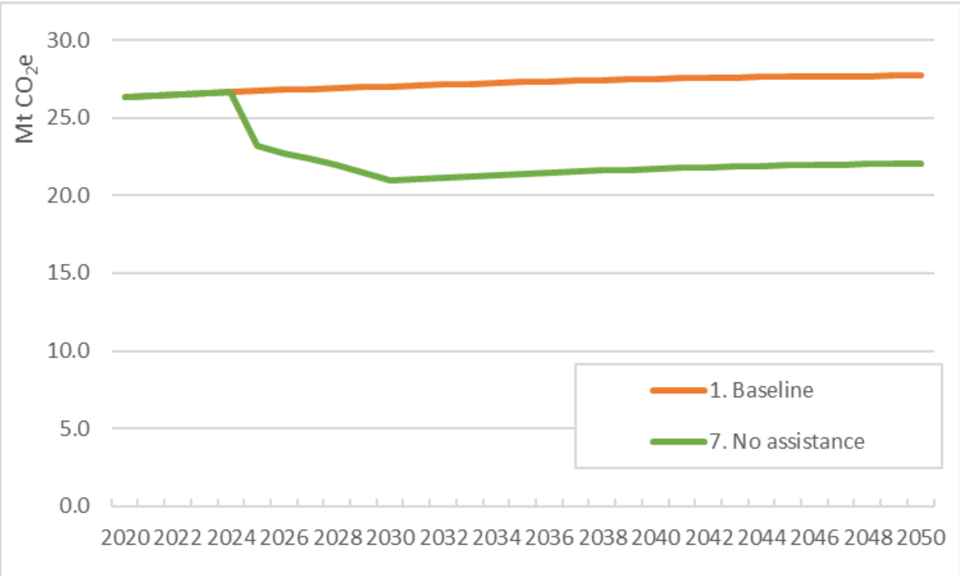
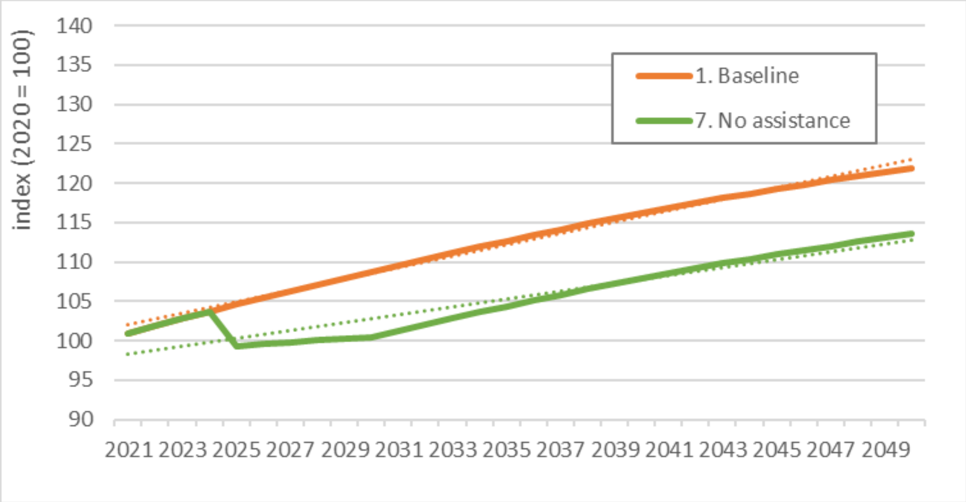



Figure 31 shows projections of the NZ dairy price between 2021 and 2050. Under this scenario, NZ dairy prices are expected to be lower than prices under the baseline scenario, while still increasing from the base year.

**Figure 31:** ***Scenario 7*** **-New Zealand producer price for dairy**




NB: emissions-price embodied

Figure 32 shows modelling results with regards to the deferral of global meat production by 2050 for the two examined meat commodities. As described earlier, NZ sheepmeat and beef production are expected to decrease significantly by 2050; global meat production is also predicted to drop but to a lesser extent. However, NZ is the only country with a projected decrease in meat production due to its high climate change action assumed in this scenario. Here, China, India, EU-27, Australia, Brazil and the United States are the main countries supplanting lost global meat production. In particular, China becomes a greater exporter of sheepmeat while Brazil is expected to export more beef.

**Figure 32:** ***Scenario 7*** **-Deferral of global meat production in 2050**

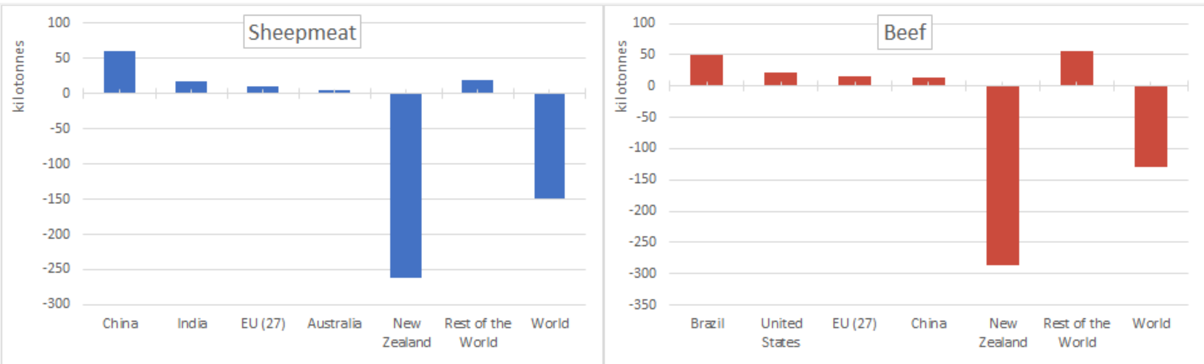



Figure 33 shows the deferral of global dairy production by 2050 for the four examined dairy commodities. As described earlier, NZ dairy production is expected to decrease by 2050; global dairy production is also predicted to fall but to a lesser extent as other third-party producers supplant lost dairy production. Not all lost production is deferred to third-party producers however. Here, India, EU-27, the United States, Argentina, Brazil, China and Japan are the main countries supplanting lost global dairy production. In particular, the United States is expected to become a greater exporter SMP. Interestingly the EU decreases its production of Cheese while under no climate constraints. This may be due to cross-price effects with Butter and WMP, where the EU is prioritising different sub-sectors of dairy production. China is projected to increase its production of WMP, while India is expected to rise butter production significantly by 2050. Finally, Argentina is expected to increase cheese production by 2050.

**Figure 33:** ***Scenario 7*** **-Deferral of global dairy production in 2050**

# 11 Conclusion

This modelling exercise has demonstrated the expected changes on domestic and global production in livestock commodities, given domestic emissions pricing and with or without global action on climate change.

Importantly, all scenarios demonstrated decreases in global emissions. While emissions leakage did occur, with decreased production in New Zealand being supplanted with production in competitors and other third party countries, on aggregate these changes did not offset emissions savings in New Zealand. Across the scenarios roughly half of the emission savings in New Zealand were reflected in global emissions savings as some lost production was fulfilled elsewhere globally.

Interestingly, all scenarios showed a decrease in total global production, which implies the ability of other countries to increase production in response to higher world prices was insufficient to replace deficits in global supply left by New Zealand and its competitors. This would imply continuing higher prices for consumers and producers due to less supply in global markets for these livestock products, and the potential for other countries to increase their production of these goods further into the future than modelled in this exercise.

In terms of deferred production, the following countries were seen to increase production given domestic and global production deficits (in order of production growth), where asterisk indicate countries which only increased production in scenarios without competitor action:

**Sheepmeat –** China, India, the European Union*, Australia

**Beef –** Brazil*, United States, the European Union*, China

**Butter –** India, the European Union*, the United States, Australia*

**Cheese –** Argentina, the United States, Brazil*

**Whole Milk Powder –** China, the European Union*, Argentina, Brazil*

**Skim Milk Powder –** the United States, India, Brazil*, Japan

The three scenarios assuming competitor action demonstrated higher world prices for goods as their production declined relative to the base scenario. This competitor action reduced the burden on New Zealand producers by offsetting some of the costs implied with the emissions price. This was particularly pronounced in Scenario 2, where New Zealand dairy prices rose above their baseline level even when accounting for the emissions price. This however was under the highest level of government assistance and did not last until the end of the modelled period in 2050, as the assistance decreased and third party countries increased their production.  This implies that while overseas action helps soften the impact of domestic emission pricing, even given the highest level of assistance and the highest level of competitor action, it is not sufficient to fully off-set the additional cost over the long term.

While all scenarios were effective at reducing New Zealand's livestock emissions, this did imply significant decreases in producer returns as production decreased, and higher prices for New Zealand consumers. Emissions from New Zealand's agricultural production is an externality whose cost has yet to be embodied in the price of agricultural goods. The implementation of an emissions price would help embody this cost in prices, yet the implied change in producer returns and consumer spending may imply a transitional period for New Zealand agricultural producers, for which the level of assistance and reduction will be important in mitigating social costs associated with sudden changes in returns.

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# Appendix

**Table A 1: Commodities in the LTEM**

| Category | Commodity |
|---|---|
| **Crop** | Wheat |
| | Maize |
| | Other Grain |
| | Rice |
| | Sugar |
| **Oilseeds** | Oilseeds |
| | Oilseed Meals |
| | Oils |
| **Meat** | Beef |
| | Sheepmeat |
| | Pig meat |
| **Poultry** | Poultry meat |
| | Eggs |
| **Dairy** | Liquid milk |
| | Butter |
| | Cheese |
| | Skim Milk Powder |
| | Whole Milk Powder |
| **Fruit** | Apples |
| | Kiwifruit |
| **Forestry** | Roundwood |
| | Sawnwood |
| | Panelwood |
| | Fuelwood |
| | Paper |
| | Pulp |

**Table A 2: Countries in the LTEM**

| | |
|---|---|
| Argentina | New Zealand |
| Australia | Norway |
| Brazil | Russian Federation |
| Canada | South Africa |
| China | Switzerland |
| European Union (27) | Turkey |
| United Kingdom | United States |
| India | Chile |
| Japan | Paraguay |
| South Korea | Uruguay |
| Mexico | Rest of the World |