



The macroeconomic impacts of the One Plan's intensive land use provisions

NZIER final report to Horizons Regional Council

July 2018

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Key points

We estimate the regional economic impacts of Table 14.2 nitrogen loss limits using a Computable General Equilibrium model...

NZIER was asked by the Horizons Regional Council to estimate the regional macro-economic impacts on farmers and commercial vegetable growers of meeting the nitrogen loss targets in Table 14.2 of the One Plan in three local economies: horticulture in the Horowhenua district, and dairy farmers in the Tararua and Rangitikei¹ districts.

Horizons Regional Council wants to understand how these estimated direct on-farm/on-orchard costs might affect the wider territorial authority economies, the Horizons economy and the New Zealand economy.

We use NZIER's computable general equilibrium (CGE) model of the New Zealand economy to estimate these economic impacts.

...which explores the direct and flow-on effects of lower on-farm production as farmers adjust

As well as the direct impacts, we also examine the indirect or flow-on effects for supplying industries (e.g. agricultural services, fertiliser production, transport, etc.) and downstream industries (primary processing, retail, construction, etc.).

Our modelling considers how resources (especially labour and capital) shift between the primary sector and other industries (manufacturing, services, etc.) as the dairy and horticulture industries becomes less competitive and profitable in the face of higher costs to meet nitrogen loss targets.

Using these direct and indirect effects, we determine the flow-on effects throughout the wider Horizons economy and the national economy on GDP, employment, wages, and household spending.

Table 1 Summary of modelling scenarios

Scenario	Industry	Targeted profitability in 2038 ²	
		Original Table 14.2	Revised Table 14.2
Tararua (Upper-Manawatū catchment)	Dairy	-24%	-8%
Rangitikei (Coastal Rangitikei Catchment)	Dairy	-17%	-8%
Horowhenua	Horticulture	-58%	N/A

Source: NZIER

¹ We didn't have all the data available to model the impacts of meeting Table 14.2 requirements for arable farmers in Rangitikei. For this reason, we only modelled impacts on dairy industry even though arable farmers will also be affected by the One Plan Table 14.2 provisions

² Shocks on productivity have been pro-rated using the share of milk production (in kg milk solid) between Upper-Manawatū catchment and Tararua district. We followed the same procedure to pro-rate the shock in Rangitikei. To estimate these ratios, we used data provided in Parminter (2018) and New Zealand Dairy Statistics (2016/2017).

Additional costs from meeting nitrogen loss targets lead to lower agricultural production...

- Dairy production falls by 28% in Tararua and by 22% in Rangitikei under the original Table 14.2 limits.
- Dairy output falls by 10% in the two regions under the revised Table 14.2.
- Commercial vegetable production in Horowhenua decreases by 64% following the implementation of the original Table 14.2.

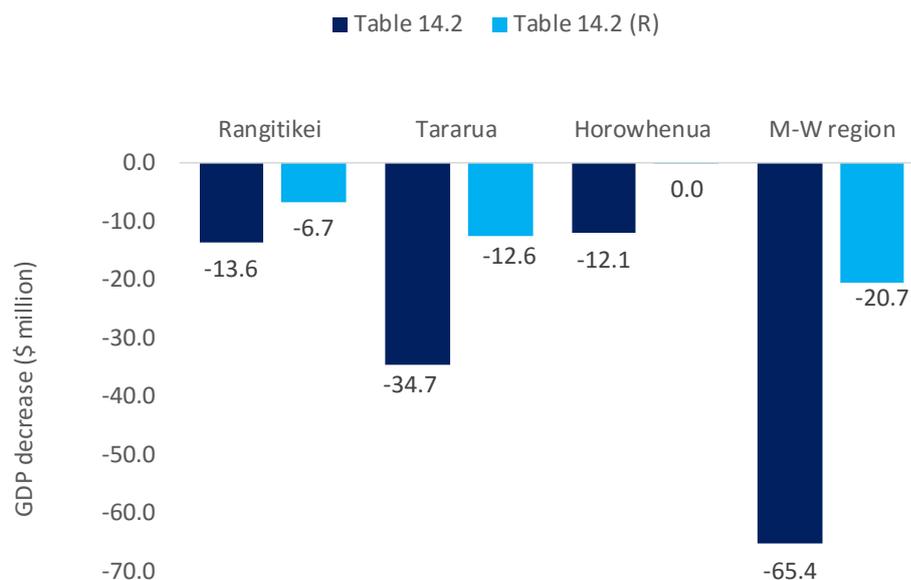
...leading to lower regional GDP and household spending

Table 2 overleaf and Figure 1 below show the negative impacts of Table 14.2 (original and revised) on regional GDP, exports and household consumption.

- GDP decreases by 4.9% or \$34.7 million in Tararua, 2.5% or \$13.6 million in Rangitikei, and 1.4% or \$12.1 million in Horowhenua.
- Regional welfare, as proxied by household spending, decreases under the original Table 14.2: consumption falls by 3.2% or \$14.6 million in Tararua, 1.0% or \$4.3 million in Rangitikei, and 1.7% or \$11.4 million in Horowhenua.
- Real wages decrease by 1.6% in Tararua, 0.5% in Rangitikei and 0.9% in Horowhenua as these economies slow and the demand for labour drops.
- GDP in the Manawatu-Wanganui region falls by \$65.4 million for the original Table 14.2 limits, and \$20.7 million for the revised limits. The region's real GDP is projected to be \$14.8 billion by 2038.

Figure 1 Impacts on GDP at the district and regional level

in \$ million



Source: NZIER, Results from CGE modelling, New Zealand Treasury Long Term Fiscal Model

Table 2 Impacts on macroeconomic variables

Indicator		GDP	Household consumption	Real wages	Exports	
Original Table 14.2	Tararua	% change	-4.9%	-3.2%	-1.6 %	-2.7%
		Level (\$m)	-\$34.7	-\$14.6	NA	-\$4.5
	Rangitikei	% change	-2.5%	-1.1%	-0.5 %	-0.2%
		Level (\$m)	-\$13.6	-\$4.3	NA	-\$0.37
	Horowhenua	% change	-1.4%	-1.8%	-0.9 %	-0.8%
		Level (\$m)	-\$12.1	-\$11.4	NA	-\$2.1
	Manawatu Wanganui region ³	% change	-0.7%	-0.4%	-0.7%	-0.5%
		Level (\$m)	-\$65.4	-\$34.1	NA	-\$14.1
	New Zealand	% change	-0.05%	-0.03%	-0.04%	-0.05%
		Level (\$m)	-\$145	-\$51.6	NA	-\$34.7
Revised Table 14.2	Tararua	% change	-1.8%	-1.1%	-0.5 %	-1.0%
		Level (\$m)	-\$12.6	-\$5.1	NA	-\$1.7
	Rangitikei	% change	-1.2%	-0.5%	-0.2 %	-0.1%
		Level (\$m)	-\$6.7	-\$2.0	NA	-\$0.19
	Manawatu Wanganui region	% change	-0.2%	-0.1%	-0.2%	-0.15%
		Level (\$m)	-\$20.7	-\$8.3	NA	-\$4.74
	New Zealand	% change	-0.02%	-0.01%	-0.01%	-0.02%
		Level (\$m)	-\$45	-\$15.5	NA	-\$12.4

Source: NZIER, Results from CGE modelling

Industries closely related also suffer from the slowdown of the dairy and horticulture industries

- When dairy and horticulture farmers meet existing Table 14.2 limits, supplying industries such as transportation and utilities also experience significant declines:
 - In Tararua they are down 4.1% and 2.9%, respectively.
 - In Rangitikei they are down 1.8% and 0.3% respectively.
 - In Horowhenua they are down 1.9% and 4%, respectively.
- Dairy products and fruit, vegetable and other food products, which are downstream industries of the dairy and horticulture industries, are also negatively affected. In Tararua, dairy products are falling by 12.3% or \$39.7

³ Manawatū-Wanganui region includes Tararua, Rangitikei, Horowhenua districts as well as Rest of Manawatu-Wanganui, which includes all the other districts (Palmerston North City, Manawatu, Wanganui, Ruapehu, Stratford, Waitomo, and Taupo). Some of these other districts experience small changes in GDP as the Tararua, Rangitikei and Horowhenua economies adjust to Table 14.2 requirements.

million. In Horowhenua, fruit, vegetable and other food products falls by 3.7% or \$1.1 million.

- These flow-on output decreases are not as strong in the case of the revised Table 14.2. Dairy processing, transportation, and utilities decline by 4.5%, 1.5% and 1.0%, respectively.
- Industries where households spend their income are also affected from the contraction of the dairy and horticulture industries.
 - Real estate is down by 1.2% in Taranaki, by 0.6% in Rangitikei and by 0.7% in Horowhenua for the existing Table 14.2 limits.
 - Retail is down by 0.1% in Taranaki, by 0.2% in Rangitikei and by 2.3% in Horowhenua.
 - Overall household consumption decreases in Taranaki (3.2%), in Rangitikei (1.1%) and Horowhenua (1.8%) as seen in Table 2.

Table 3 below presents the industry impacts for the sum of the three directly affected districts, for the Manawatu-Wanganui region and New Zealand economy.

Table 3 Industry impacts

Industry	Type	District impacts (%)		Manawatu-Wanganui region impacts (%)		New Zealand impacts (%)	
		Original Table 14.2*	Revised Table 14.2**	Original Table 14.2*	Revised Table 14.2**	Original Table 14.2*	Revised Table 14.2**
Utilities	Supplying industries	-0.32%	-0.13%	-0.21%	-0.06%	-0.15%	-0.04%
Motor vehicle		-2.49%	-0.03%	-0.22%	-0.04%	-0.08%	-0.02%
Road & rail		-1.51%	-0.50%	-0.32%	-0.11%	-0.07%	-0.02%
Wholesale		-1.58%	-0.23%	-0.26%	-0.05%	-0.03%	-0.01%
Fertilisers		-1.05%	-0.21%	-0.50%	-0.10%	-0.06%	-0.01%
Ag services		-0.63%	-0.30%	-0.43%	-0.16%	-0.12%	-0.02%
Dairy product manufact.	Downstream industry	-9.55%	-3.44%	-3.42%	-1.27%	-0.38%	-0.15%
Retail	Household expenditure	-1.44%	-0.10%	-0.43%	-0.04%	-0.07%	-0.02%
Real estate		-1.07%	-0.30%	-0.36%	-0.10%	-0.06%	-0.02%
Sheep and beef	Competing industries (for dairy or horticulture)	1.26%	0.41%	0.74%	0.24%	0.16%	0.05%
Poultry		5.03%	0.25%	3.13%	0.17%	0.33%	0.03%
Forestry & logs		0.20%	0.05%	0.12%	0.03%	0.03%	0.01%
Fruit, vegetable & food products		-0.06%	0.40%	0.06%	0.21%	0.05%	0.03%
Seafood products		0.84%	0.02%	0.21%	0.03%	0.12%	0.03%
Dairy	Shocked industries	-12.89%	-5.25%	-6.98%	-2.85%	-0.37%	-0.16%
Horticulture		-46.47%	0.24%	-23.42%	0.14%	-0.43%	0.03%

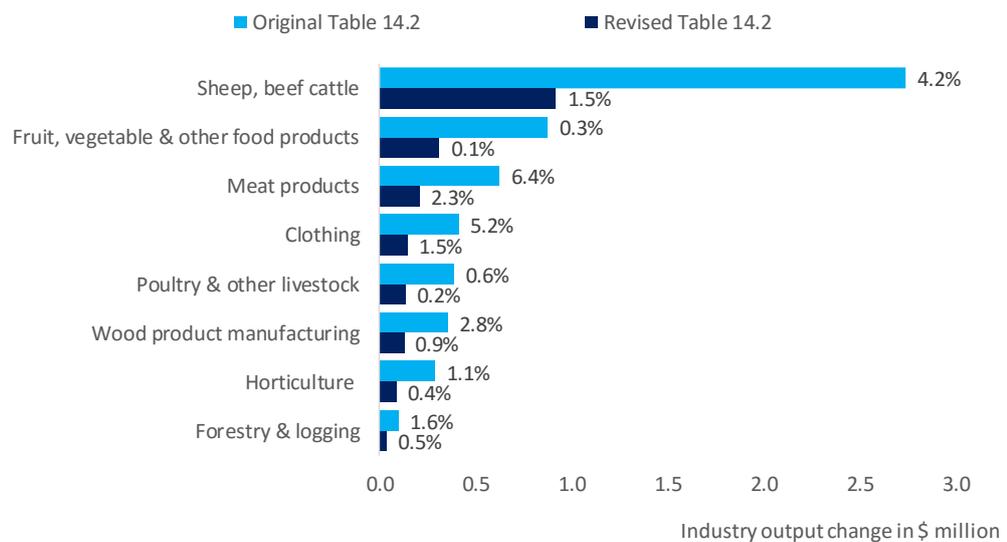
Source: NZIER, Results from CGE modelling

Competing industries gain from the decrease of the dairy and horticulture industries

With smaller dairy and horticulture industries, more resources become available for other parts of the economy, and at lower cost, allowing other industries to grow (Figure 2, Figure 3, and Figure 4).

Figure 2 Gains for selected competing industries in Taranaki

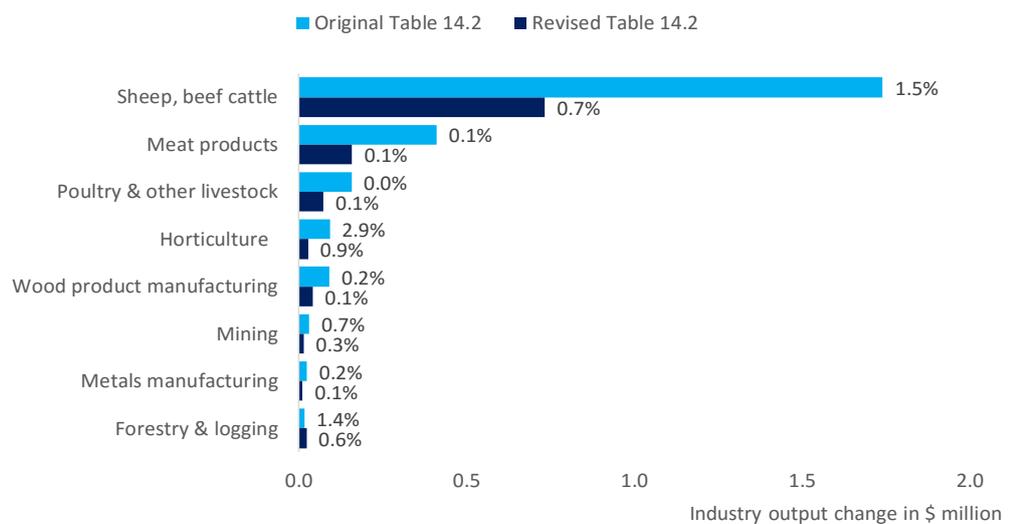
Change in industry output in \$ million and in percentage



Source: NZIER, Results from CGE modelling

Figure 3 Gains for selected competing industries in Rangitikei

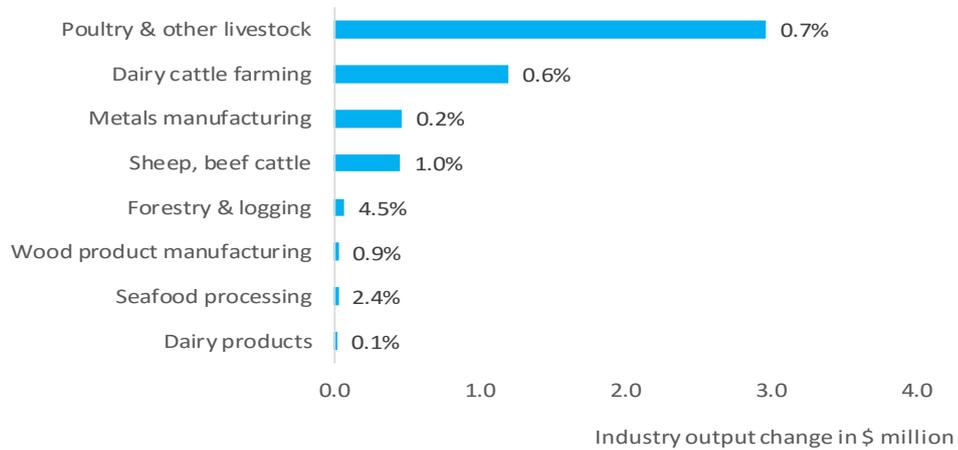
Change in industry output in \$ million and in percentage



Source: NZIER, Results from CGE modelling

Figure 4 Gains for selected competing industries in Horowhenua

Change in industry output in \$ million and in percentage, under the original Table 14.2



Source: NZIER, Results from CGE modelling

A note of caution

As we were missing some information for dairy in Rangitikei and horticulture in Horowhenua, we used the information provided by Parminter (2018) and NZ Dairy Statistics (2016/2017) to design indicative scenarios.

As more information and data becomes available on the on-farm costs associated with this measure, especially in the case of the revised Table 14.2 targets, we will be able to carry out further economic modelling as required.

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1. Background and objectives

1.1. Our task

NZIER was asked by the Horizons Regional Council to estimate the regional macro-economic impacts on farmers and commercial vegetable growers of meeting the nitrogen loss targets in Table 14.2 of the One Plan in three local economies: horticulture in the Horowhenua district, dairy farmers in the Tararua and Rangitikei⁴ districts.

Horizons Regional Council wants to understand how these estimated on-farm/on-orchard costs might affect the wider territorial authority economies, the Horizons economy and the New Zealand economy.

In this report, we examine the indirect or flow-on effects for supplying industries (e.g. agricultural services, fertiliser production, transport, etc.) and downstream industries (primary processing, retail, construction, etc.).

Our modelling also considers how resources (especially labour and capital) shift between the primary sector and other industries (manufacturing, services, etc.) as the dairy and horticulture industries becomes less competitive and profitable in the face of higher costs to meet nitrogen loss targets.

Using these direct and indirect effects, we determined the flow-on effects throughout the wider Horizons economy and the national economy on GDP, employment, wages, and household spending. This gives us the macroeconomic impacts that you are interested in for your review.

⁴ We did not have all the data available to model the impacts of meeting Table 14.2 requirements for arable farmers in Rangitikei. For this reason, we only modelled impacts on dairy even though arable farmers will also be affected by the Table 14.2 provisions.

2. Methodology and scenarios

2.1. We used our computable general equilibrium model to assess the costs of meeting the new nitrogen loss targets

We used NZIER's regional computable general equilibrium (CGE) model to assess the regional and national economic impacts of meeting nitrogen loss targets from Table 14. 2 (Original and Revised versions) of the One plan.

CGE modelling is our recommended method for conducting policy analysis or sectoral impact studies, as it delivers more conservative, but more realistic, estimates of net benefits than commonly-used (and widely criticised) alternatives such as multiplier analysis.

Our CGE model contains information on 106 industries and 201 commodities within the economy, incorporates trade and financial linkages to world markets, and estimates price responses to demand or supply shocks. It is described in more detail in Appendix B.

Table 4 below presents the values (in million \$) used as our 2017 baseline for different macro-economic indicators and industry outputs. The model is based on the latest Input-Output table and is adjusted with the most recent National Accounts table from New Zealand Statistics. These values are presented at the district, regional and national levels.

Table 4 CGE model database

2017, in \$ million

Indicator	Tararua	Rangitikei	Horowhenua	Manawatu-Wanganui	New Zealand
GDP	\$707	\$555	\$874	\$9,410	\$264,695
Household consumption	\$457	\$412	\$653	\$7,510	\$152,482
Exports	\$187	\$169	\$267	\$3,079	\$70,314
Imports	\$180	\$162	\$252	\$2,901	\$69,077
Labour	\$243	\$207	\$347	\$4,438	\$114,967
Capital	\$282	\$180	\$347	\$3,199	\$107,872
Dairy industry output	\$183	\$108	\$179	\$854	\$12,286
Horticulture industry output	\$5	\$3	\$50	\$114	\$3,467
Total output (all industries)	\$1,621	\$1,82	\$1,841	\$18,019	\$502,789
Dairy GDP	\$93	\$55	\$91	\$342	\$6,265
Horticulture GDP	\$2	\$1	\$19	\$41	\$1,322
GDP for all industries	\$640	\$495	\$779	\$7,686	\$241,719

Source: NZIER, Input-Output table 2013, National Accounts 2017 from New Zealand Statistics

2.2. We modelled the costs of meeting N-loss limits as a negative shock on profitability

Horizons Regional Council provided us with a report (Parminter, 2018) which looks at on-farm costs in Tararua, Rangitikei and Manawatū districts in response to three policy situations:

- Before undertaking management changes to achieve One Plan nitrogen loss requirements
- After undertaking management changes to achieve One Plan nitrogen loss requirements in Table 14.2
- After undertaking management changes to achieve One Plan nitrogen loss requirements in a proposed revision of Table 14.2(R).

The industries being considered in this report are:

- Dairy in the Upper Manawatū Catchment of the Tararua district
- Dairy in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawatū districts (part)
- Horticulture in the Horowhenua district.

We used the figures provided by Parminter (2018) to estimate the expected loss in profitability in the dairy industry in Tararua and Rangitikei under the original Table 14.2 targets and the revised Table 14.2 targets of the One Plan.

Table 5 below provides a summary of our modelling scenario.

- The first set of simulations consists of imposing a shock on land productivity for the dairy industry in Tararua and Rangitikei, and horticulture in Horowhenua⁵ so that it reflects the profitability losses expected from meeting the nitrogen loss targets of the original Table 14.2.
- In the second set of simulations, we impose a shock on the land productivity for the dairy industry in Tararua and Rangitikei so that it reflects the profitability losses expected from meeting the nitrogen loss targets of the revised Table 14.2.
- We do not run any simulation for horticulture in Horowhenua for the revised Table 14.2 in this situation as no additional change is expected compared with the original Table 14.2 based on Parminter (2018).
- Parminter (2018) has produced farm-level impacts for one, five, ten and twenty years. As our CGE model is static, it can only look at 'before' (i.e. current situation) and 'after'. For our scenario design, we have used results provided for year 20 (i.e. 2038).

Further explanation on our modelling approach can be found in Appendix B.5

⁵ As we did not have all the data available for the simulation, we designed an indicative scenario and shocked productivity so that it reflected a 58% decrease in profitability in the horticulture industry. This figure is most likely over-estimated, and we will refine this scenario when we get additional data.

Table 5 Summary of modelling scenarios

Scenario	Industry	Targeted profitability in 2038		
		Shock	Original Table 14. 2	Revised Table 14.2
Tararua (Upper-Manawatū catchment)	Dairy	Productivity	-24%	-8%
Rangitikei (Coastal Rangitikei Catchment)	Dairy	Productivity	-17%	-8%
Horowhenua	Horticulture	Productivity	-58%	N/A

Source: NZIER

2.3. How we analysed the modelling results

Our analysis of the modelling results is systematic as we track the impacts as they flow through the economy.

Beginning with the **direct impacts** on the dairy and horticulture industries, **at the district level**, we look at consumption, trade, labour and capital factor markets to see how these two industries respond to the introduction of new nitrogen-leaching targets.

We then analyse the **flow-on or indirect impacts** on other industries, at the district level. We split the indirect impacts into the following industry categories:

- **Supplying industries** – industries that supply intermediate inputs are likely to be negatively affected by weaker dairy and horticulture industries. These are industries such as packaging and the fertiliser industry.
- **Household expenditure industries** – industries that households spend money on are likely to be negatively affected from the decreased income that comes through lower employment and wages, and the decreased returns to capital from a deterioration of the dairy and horticulture industries.
- **Competing export industries** – industries that compete for resources (such as land and labour) with the dairy and horticulture industries gain from the implementation of the new nitrogen loss targets.

We then examined the **regional and national macroeconomic effects**. Here we report both value-added (GDP) and welfare (private and public consumption) measures.

3. Results

The simulation results confirm that the introduction of the Table 14.2 targets in the One Plan (original and revised) would have negative effects on the regional and national economies.

Compared to what would have happened without the implementation of the nitrogen loss targets, the regional economies are smaller.

Detailed results showing the impacts on industry output are presented in tabular form in Appendix C. These results show how resources move between competing industries in the regional economies as the dairy and horticulture industries are negatively affected by the new nitrogen loss targets in Table 14.2 of the One Plan, for both the original and revised versions of the table.

3.1. Impacts on dairy & horticulture

Agricultural production falls due to higher costs of production from meeting new nitrogen loss requirements, and from farmers spending more time on implementing new management practices to reduce their use of fertilisers.

As land productivity decreases and production costs rise, farms' capacity falls.⁶ The more reliant a farm is on fertilisers as an input, the more output is likely to drop. Dairy and horticulture exports fall, due to the overall drop in dairy and horticulture production.

Industries closely related to the dairy and horticulture industries (e.g. rural retail, fertilisers) also suffer from the primary sector slowdown.

Both effects will reduce real GDP, employment and household consumption in the region. However, the overall effect on GDP will be limited as the affected agricultural industries account for about 5% of total GDP and meeting the nitrogen loss requirements impacts only a small portion of the affected industries' overall inputs to production.

Other industries will benefit at the margin from the contraction in the dairy and horticulture industries, as more resources (labour, capital, land) become available for producing other goods and services.

3.1.1. Industry output and contribution to GDP

To meet the revised nitrogen loss requirement targets, dairy farmers in Tararua and Rangitikei, as well as commercial vegetable growers in Horowhenua will have to implement new management and agricultural practices and use less fertiliser. Farmers will therefore face lower productivity and higher production costs.

In the dairy industry, industry output decreases by 28% in Tararua under the original Table 14.2 targets and by 10% under the revised Table 14.2 targets.

⁶ Our model has a 'fixed proportions' production structure, which implies that as production costs increase, output falls as production becomes less profitable. Alternative production structures could be employed that allow producers to simply absorb higher costs and maintain production levels by dipping into savings or borrowing more, but this is not a standard approach to CGE modelling.

In Rangitikei, dairy farmers experience a 22% reduction in their outputs under the original Table 14.2 targets and a 10% output reduction under the revised Table 14.2 targets.

Results of the indicative scenario we have designed for horticulture in the Horowhenua district suggest a 64% output decrease following the implementation of the original Table 14.2 targets.

Following the implementation of the original Table 14.2 (revised Table 14.2) targets, the contribution of the dairy industry, as a share of regional GDP, falls by 4% (1.5%) in Tararua and by 2.4% (1.2%) in Rangitikei.

In Horowhenua, the regional GDP contribution of the horticulture industry decreases by 1.5% under the original Table 14.2 targets.

3.1.2. Labour demand and capital usage

Table 6 shows a significant decrease in labour demand, wages and capital usage for dairy farmers in Tararua and Rangitikei, and commercial vegetable growers in Horowhenua with the implementation of both original and revised versions of Table 14.2.

Under the original Table 14.2 targets, labour demand reduces by 23.2% in Tararua and by 18.8% in Rangitikei along with a decrease in wages of similar magnitude in the two regions. Capital usage decreases by 23.8% in Tararua and by 19.0% in Rangitikei.

Table 6 Labour demand and capital usage in dairy and horticulture

Percentage change

Indicator	Original Table 14.2			Revised Table 14.2	
	Tararua (dairy industry)	Rangitikei (dairy industry)	Horowhenua (horticulture)	Tararua (dairy industry)	Rangitikei (dairy industry)
Labour demand	-23.2 %	-18.8 %	-58.2 %	-8.1 %	-9.0 %
Capital usage	-23.8 %	-19.0 %	-58.4 %	-8.4 %	-9.1 %
Wages	-24.5 %	-19.2 %	-58.6 %	-8.6 %	-9.1 %

Source: NZIER, Results from CGE modelling

3.2. District impacts

3.2.1. District direct impacts on the dairy and horticulture industries

At the district level (Table 7), the additional costs to dairy farmers and commercial vegetable growers in meeting the nitrogen loss targets from Table 14.2 in dairy and horticulture result in:

- Real GDP decreasing by 6.1% or \$43.1 million in Tararua, 3.2% or \$17.7 million in Rangitikei, and 2.0% or \$17.5 million in Horowhenua.

- Regional welfare, as proxied by household spending, decreases with the original Table 14.2 (revised Table 14.2):
 - In Tararua, household consumption falls by 3.2% or \$14.6 million (1.1% or \$5.1 million under the revised Table 14.2)
 - In Rangitikei, household consumption falls by 1.0% or \$4.3 million (0.5% or \$2 million under the revised Table 14.2)
 - In Horowhenua, household consumption falls by 1.7% or \$11.4 million under the original 14.2 Table.
- Real wages decreasing by 1.6% in Tararua, by 0.5% in Rangitikei and by 0.8% in Horowhenua.

Macroeconomic effects from the targets in the revised Table 14.2 are also negative for the different indicators; but are only a third of the magnitude of the costs of meeting the original Table 14.2 targets.

Table 7 Impacts on macroeconomic indicators at the regional level

Indicator	Original Table 14.2			Revised Table 14.2	
	Tararua (%change)	Rangitikei (% change)	Horowhenua (% change)	Tararua (% change)	Rangitikei (% change)
Real GDP	-6.1 %	-3.2 %	-2.0 %	-2.2%	-1.6 %
Household consumption	-3.2%	-1.1 %	-1.7 %	-1.1 %	-0.5 %
Exports	-2.7%	-0.2 %	-0.8 %	-1.0 %	-0.1 %
Imports	-1.5 %	-0.6 %	-0.5 %	-0.5 %	-0.3 %
Real wage	-1.6 %	-0.5 %	-0.9 %	-0.5 %	-0.2 %

Indicator	Original Table 14.2			Revised Table 14.2	
	Tararua (\$m change)	Rangitikei (\$m change)	Horowhenua (\$m change)	Tararua (\$m change)	Rangitikei (\$m change)
Real GDP	-\$43.1	-\$17.7	-\$17.5	-\$15.5	-\$8.8
Household consumption	-\$14.6	-\$4.3	-\$11.4	-\$5.1	-\$2.0
Exports	-\$4.0	-\$0.37	-\$2.1	-\$1.7	-\$0.19
Imports	-\$2.7	-\$0.9	-\$1.3	-\$0.9	-\$0.5
Real wage	NA	NA	NA	NA	NA

Source: NZIER, Results from CGE modelling

3.2.2. District indirect impacts on other industries

The economic effects from the contraction of the dairy and horticulture industries are not just contained within these industries; they are more widely felt throughout the economy.

The indirect impacts of the nitrogen loss targets from Table 14.2 in dairy in Taranaki are widespread across other industries within the economy (see Table 8):

- **Supplying industries** – Other transport, utilities and motor vehicles supply the dairy industry with intermediate goods and services. These industries are negatively affected with significant declines, down 4.1%, 2.9% and 2.6%, respectively.
- The output decrease is not as strong in the case of the revised Table 14.2 targets. Other transportation, utilities and motor vehicle decline by 1.5%, 1.0% and 0.9% respectively.
- **Downstream industries** – Dairy processing output falls by 12.3% under Table 14.2 and by 4.5% with the revised Table 14.2 limits.
- **Household expenditure industries** – Industries where households spend their income are also affected from the contraction of the dairy and horticulture industries.
 - Real estate is down by 1.2% under Table 14.2 and by 0.4% under the revised Table 14.2.
 - Retail industry output is down by 0.1% with the original Table 14.2 limits and by 0.01% under the revised version.
 - Overall household consumption decreases in Taranaki by 3.2% with the original Table 14.2 limits; and by 1.1% with the revised Table 14.2.
- **Competing industries** – These industries gain from the decrease in the dairy industry in Taranaki.
 - In the primary sector, sheep and beef⁷, the second biggest industry in Taranaki after dairy, grows by 1.1%.
 - Two other important competing industries in the primary sector, poultry⁸ and forestry⁹, increase by 2.7% and 0.3%, respectively.
 - In services, finance and insurance grows by 1.6%.
- Output growth of the competing industries is about a third under the revised Table 14.2 targets compared to the original Table 14.2 limits.

The effects of the revised Table 14.2 are lower in magnitude as the nitrogen loss targets are less ambitious than the original Table 14.2 hence, less costly to implement by farmers.

Additional results for the dairy industry in Rangitikei and horticulture in Horowhenua can be found in Table 12 and Table 13 in Appendix C.

⁷ The output of the sheep and beef industry in Taranaki is worth \$247 million in 2017.

⁸ The output of the poultry industry in Taranaki is worth \$13.9 million in 2017.

⁹ The output produced in the forestry industry in Taranaki is worth \$26.5 million in 2017.

Table 8 Indirect impacts on selected industries in the Tararua district

Percentage change in industry output due to the contraction of the dairy and horticulture industries

Industry	Type	Impacts (%)	
		Original Table 14.2	Revised Table 14.2
Other transport	Supplying industries	-4.1%	-1.5%
Utilities		-2.9%	-1.0%
Motor vehicle		-2.6%	-0.9%
Road, rail transport		-2.3%	-0.9%
Wholesale		-0.9%	-0.3%
Fertilisers		-0.8%	-0.2%
Agriculture services		-0.7%	-0.1%
Dairy product manufacturing	Downstream industry	-12.3%	-4.5%
Retail	Household expenditure	-0.1%	-0.01%
Real estate		-1.2%	-0.4%
Sheep and beef	Competing industries	1.1%	0.4%
Poultry		2.8%	0.9%
Forestry and logging		0.4%	0.1%
Fruit, vegetable and food products		6.4%	2.3%
Horticulture		5.2%	1.5%
Seafood products		4.2%	1.4%

Source: NZIER, Results from CGE modelling

3.2.3. District trade

As shown in Figure 5, meeting the nitrogen loss targets in the original and revised Table 14.2 of the One Plan also affects trade. As seen previously, the dairy and the horticulture industries face lower productivity and lower production because of higher costs of production. This translates into a reduced export supply in the industry.

Figure 5 shows the trade effects of meeting the original Table 14.2 targets in Tararua. Exports of milk and other dairy products are substantially affected with a decrease of 18.9% and 11.0%, respectively. Exports of products coming from supplying industries are also negatively affected. Exports of food products decrease by 4.5% and grain products by 3.5%.

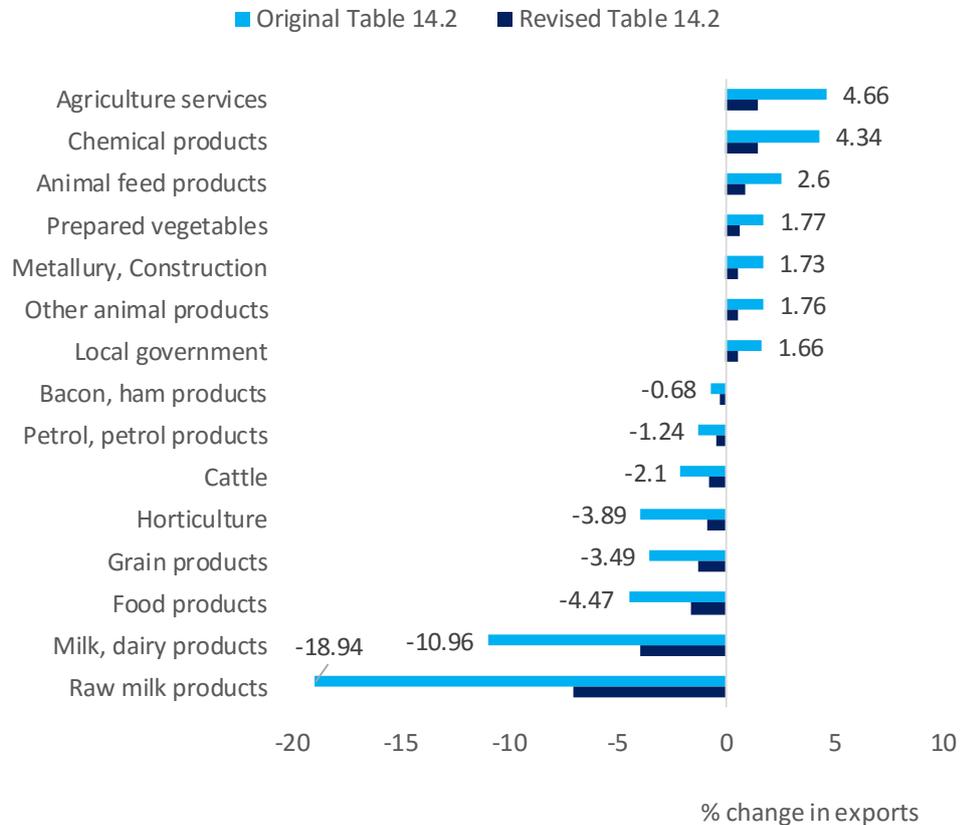
Trade effects for the revised Table 14.2 targets are about a third of the original targets.

Results for the Rangitikei and Horowhenua districts are presented in Figure 13 and Figure 14 in Appendix C.

The decline in agricultural exports is partly offset by small increases in exports across many manufacturing and services industries due to the shift of resources away from the dairy and horticulture industries into other industries of the economy.

Figure 5 Trade effects on selected products in the Taranua district

Percentage change in exports



Source: NZIER, Results from CGE modelling

3.3. Regional impacts

At regional level (see Table 9 and Figure 6), the additional costs for dairy and horticulture in meeting the nitrogen loss targets from the Table 14.2 (revised Table 14.2) result in:

- Manawatu-Wanganui’s 2017 nominal GDP decreasing by \$65 million (\$21 million), relative to what it would have been had the dairy and horticulture industries stayed at their 2017 levels.
- Manawatu-Wanganui’s welfare, as proxied by private and public consumption, being \$34 million (\$8 million) lower than it would have been otherwise.
- Regional real wages decreasing by 0.74% (-0.20%).
- GDP in the Manawatu-Wanganui region falls by \$65.4 million for the original Table 14.2 limits, and \$20.7 million for the revised limits. The region’s real GDP is projected to be \$14.8 billion by 2038.

Table 9 Impacts on Manawatu-Wanganui macroeconomic indicators

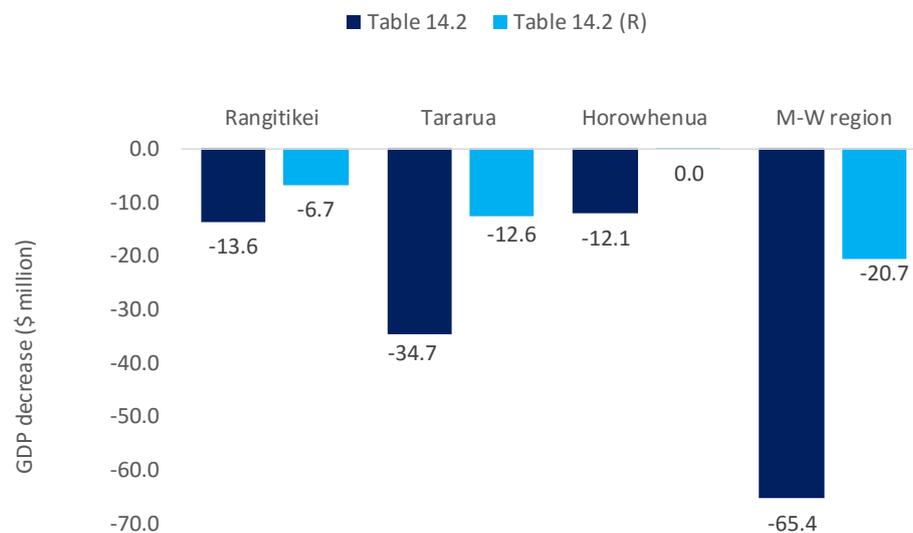
Percentage deviation due to the contraction of the dairy and horticulture industries

Indicator	Original Table 14. 2		Revised Table 14.2	
	% change	Levels change, \$m	% change	Levels change, \$m
Real GDP	-0.86%	N/A	-0.26%	N/A
Nominal GDP	-0.69%	-\$65	-0.22%	-\$21
Private consumption	-0.45%	-\$34	-0.11%	-\$8
Exports	-0.45%	-\$14	-0.15%	-\$5
Imports	-0.37%	-\$10	-0.11%	-\$3
Real wage	-0.74%	N/A	-0.20%	N/A
Capital	-0.71%	-\$23	-0.21%	-\$7

Source: NZIER, Results from CGE modelling

Figure 6 Impacts on GDP at the district and regional level

in \$ million



Source: NZIER, Results from CGE modelling

3.4. National impacts

At the national level (see Table 10) the additional costs for dairy and horticulture in meeting the nitrogen loss targets from the Table 14.2 (revised Table 14.2) result in:

- New Zealand’s 2017 nominal GDP decreasing by \$361 million (\$120 million), relative to what it would have been had the dairy and horticulture industries stayed at their 2017 levels.
- New Zealand’s welfare, as proxied by private and public consumption, being \$84 million (\$28 million) lower than it would have been otherwise.
- Economy wide real wages decreasing by 0.04% (-0.01%).
- Significantly, the economic effects from the contraction of the dairy and horticulture industries, including wage decreases, are not just felt within the industry itself, but more widely throughout the economy.

Table 10 Impacts on New Zealand macroeconomic indicators

Percentage deviation due to the contraction of the dairy and horticulture industries

Indicator	Original Table 14. 2		Revised Table 14.2	
	% change	Levels change, \$m	% change	Levels change, \$m
Real GDP	-0.03%	N/A	-0.01%	N/A
Nominal GDP	-0.06%	-\$361	-0.02%	-\$120
Private consumption	- 0.03%	-\$84	-0.01%	-\$28
Exports	-0.05%	-\$150	-0.02%	-\$60
Imports	-0.03%	-\$140	-0.01%	-\$47
Real wage	-0.04%	N/A	-0.01%	N/A
Capital	-0.03%	-\$34	-0.01%	-\$11

Source: NZIER, Results from CGE modelling

Appendix A References

Ford, Stuart. (2017). Farm scale economic impact analysis of One Plan intensive land use provisions. The Agribusiness Group.

Parminter, Terry (2018), Regional macroeconomic report, memo from KapAg Ltd for Horizons Regional Council.

New Zealand dairy statistics 2016/2017,

<https://www.dairynz.co.nz/media/5788533/nz-dairy-statistics-2016-17-web.pdf>

Appendix B CGE models

B.1 What are CGE models?

To measure how changes in one part of a regional or national economy flow through the rest of the economy, we use CGE models.

CGE models are data-driven and used to capture the effects of a new policy or technology or other external shocks affecting economic activity. They capture the economy-wide effects of changes ('shocks' in modelling jargon) directly on the affected industry, as well as indirectly on supplying industries, competing industries, and factor markets (labour and capital).

CGE models also estimate the effect of a shock on macroeconomic variables such as GDP, employment, wages and trade.

CGE models are a powerful tool, allowing economists to explore empirically many issues on which econometrics or multiplier analysis would be unusable. For these reasons, CGE models have become widely used internationally (e.g. by OECD, IMF, World Bank) for economic impact analysis.

B.2 Why do we prefer CGE over multipliers?

Multiplier studies¹⁰ are popular for economic impact analysis as they are relatively cheap and produce appealing big figures. However, they are based on several assumptions which requires them to be interpreted and considered with considerably care.

Key caveats include that multiplier studies:

- Do not consider any adjustment path between the status quo and the future state of the economy
- Do not consider the impacts of policy changes on the price of goods, services, intermediate inputs, labour (wages) and capital.
- Assume that land, labour and capital are available in unlimited quantities, and at no additional cost to firms
- Cannot consider the opportunity cost of using additional resources in one industry on the rest of the economy – there are almost never any losers (i.e. contracting industries) in multiplier studies.

Because of these assumptions, multipliers overestimate the impacts of a change in a particular industry on the rest of the economy. Both the Ministry of Business, Innovation and Employment (MBIE) and Treasury have highlighted the inherent flaws in using multiplier studies for serious economic analysis.¹¹ NZIER no longer offers

¹⁰ Also known as 'input-output studies'.

¹¹ For an overview of these weaknesses, see the [New Zealand Treasury](#) and [MBIE](#). Both documents, and Gretton (2013), clearly state that multipliers over-state economic impacts and thus lack credibility for economic analysis. Or in Treasury's words: "Unless there is significant unemployment of people with the requisite skills, it is therefore likely that multiplier effects do not exist".

multiplier-based analysis to our clients as they no longer align with our independence and reputation for delivering high quality, data-driven analysis.

For all these reasons, we prefer to use CGE models.

A CGE model provides an estimation of opportunity costs (between action and inaction), winners and losers. Resources are limited. It also considers price impacts of shocks and can capture regional linkages between industries as well as spill-over effects.

The results from CGE modelling are therefore more likely to stand up to scrutiny from decision makers. This is crucial when you are looking to secure funding or to influence policy decisions.

NZIER's CGE models are highly regarded amongst government agencies with whom we have worked for to conduct policy analysis or sectoral impact studies. This includes MBIE, Treasury, the Ministry of Foreign Affairs and Trade, the Ministry for Primary Industries and the Ministry for the Environment.

We also regularly work with private sector firms to provide them with economic evaluations of their activities. Some recent examples of our CGE work include:

- An economic impact analysis of expanding the Wellington International Airport of for Air New Zealand
- Analysis of growth in NZ wine sector for New Zealand Winegrowers
- Analysis of Sky City Auckland's National Convention Centre and the Queenstown Convention Centre
- Value of irrigation in New Zealand: an economy-wide assessment
- Assessing the impact of the Canterbury rebuild at the regional and national level
- Estimating the impact of the Marlborough aquaculture industry on the regional and national economy.

B.3 How do CGE models work?

A CGE model consists of equations which describe model variables. It also uses detailed data on the structure of the economy that is consistent with these model equations.

This data provides a snapshot of the economy in a particular year, which is used as a starting point for a baseline (or business as usual (BAU)) against which to compare policy simulations or economic changes.

The model data is linked together through a set of equations which capture how the economy evolves over time in response to a shock. These equations, which are based on the economic theory of general equilibrium, ensure supply and demand for goods, services and factors of production in the economy are balanced, and determine how firms and households react in response to changes in incentives.

Most CGE models are written and solved in a specific software system, usually GAMS¹² or GEMPACK.¹³

¹² General Algebraic Modelling System: <https://www.gams.com/>

¹³ General Equilibrium Modelling PACKage: <https://www.copsmodels.com/gempack.htm>

In any CGE model, we must choose as to what is to be determined within the model (the endogenous variables) and what is to be considered external to the model (the exogenous variables). A CGE model is just a way of explaining the endogenous variables in terms of the exogenous variables.

Where we draw the line between endogenous and exogenous variables, and which ones can vary or have to remain fixed, depends on a number of factors, including the purpose for which the model simulations are to be used. The choice that we make is called the model closure.

Determining the closure is a key part of any modelling exercise and it is very important that the modeller be transparent about what is a result of the modelling and what has been imposed by assumption via the closure.

The difference between the initial and the new equilibrium can then be analysed to determine the effect of the shock on a range of economic indicators, such as GDP, employment, wages and living standards.

B.4 Our regional CGE model TERM-NZ

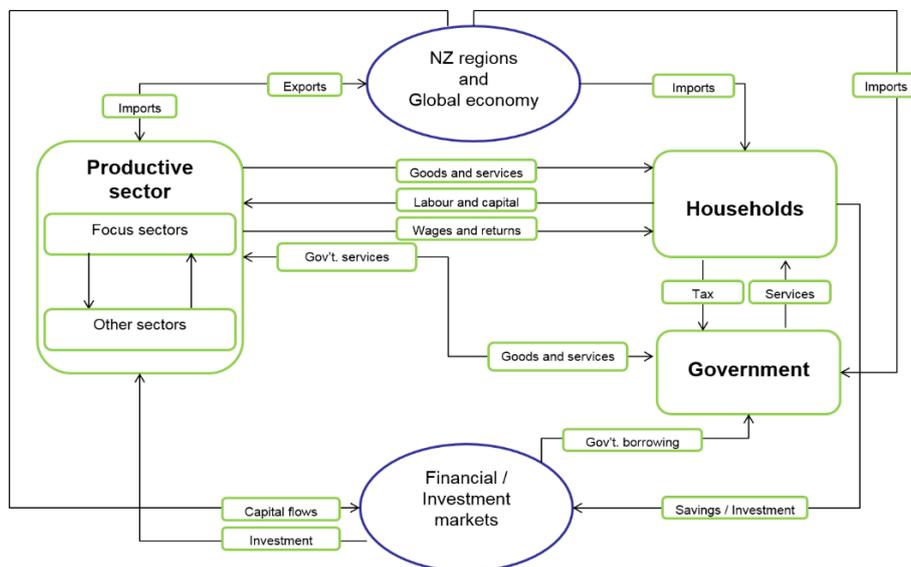
NZIER's TERM-NZ¹⁴ model is the only bottom-up regional CGE model of the New Zealand economy. TERM-NZ is based on a Statistics New Zealand's Input-Output table that identifies the structure of the industries involved. It contains information on 106 industries, 201 commodities and 15 regions, including the Manawatū-Whanganui regional economy.

TERM-NZ model is a bottom-up regional model, in which each of fifteen regions is modelled as its own economy, but all the regions are connected through inter-regional trade and flows of capital and labour. National results are the summation of the regional results.

Figure 7 shows how the model captures the complex and multidirectional flows between the various actors of each regional economy and how they interact with the rest of New Zealand and the rest of the world.

¹⁴ TERM-NZ stands for "The Enormous Regional Model" of the New Zealand economy. It was developed at NZIER by Dr Erwin Corong based on the original Australian TERM model created by Professor Mark Horridge of the Centre of Policy Studies, Victoria University-Melbourne, Australia. <http://www.copsmodels.com/term.htm>. NZIER maintains close connections with the Centre, ensuring that our modelling techniques reflect international best-practice.

Figure 7 Our CGE model represents the circular flows between all the agents and activities in the economy



Source: NZIER

B.5 Our modelling approach

B.5.1 Business as usual 2017

We want to identify the economic impacts of the current and proposed One Plan nutrient management policies and rules on the local, regional and national economies.

We first need to develop a baseline or BAU picture of the economy with the current One Plan measures. To do so, we calibrate our model of the Horizons economy and its territorial authorities to the latest available data from Statistics New Zealand.

As part of our calibration process, we split the Horizons regional economy into separate economies for Horowhenua, Tararua, Rangitikei and the rest of Manawatū-Whanganui region. To disaggregate the Horizons regional economy into these four sub-regions, we use detailed local employment data from Statistics New Zealand.¹⁵

Since up-to-date industry GDP numbers are not available at the district level, we assume that industries within Tararua, Horowhenua, Rangitikei and the rest of Manawatū-Whanganui region grow at the same rate as the industries at the Manawatū-Whanganui (regional) level. We use this assumption to estimate the share of industry, exports, inventory, government and consumption, within these four sub-regions, based on the local employment data.

This allows us to ensure we correctly benchmark the size of the various agricultural industries and gives us a BAU snapshot of the local, regional and national economies under the current One Plan measures.

While TERM-NZ is computationally efficient, running and solving the model for the full 106-industry, 201-commodity and 15-region database would be slow. We therefore

¹⁵ Latest data (February 2017) can be found at this link: [Business demography statistics](#)

aggregate the industries and commodities to only focus on those relevant to this report and to speed up the computational process.

B.5.2 Scenario design

We want to see how the impact of meeting existing One Plan provisions scenarios in 2038 (year 20) differs from the BAU situation. To identify those scenarios and evaluate the additional on-farm/orchard costs, we use information from reports you have commissioned.

We weight these costs up from the farm level to the industry level. This is because in our CGE model, our dairy farming industry is not split by land type. We have just one aggregate dairy farming industry. We use the data you provided us on the milk production of the various dairy farm types by territorial authority.

B.5.3 Economic impact modelling of additional costs to farmers and commercial vegetable growers

We impose the additional costs to dairy farmers for the dairy industry in Tararua and Rangitikei, and horticulture industry in Horowhenua. The resulting decrease in output and margins, for each industry, gives us the direct costs to farmers of the consenting regime (for those without consent).

For the Tararua and Rangitikei dairy farms, we model a dairy industry productivity decrease which is a weighted average of the productivity reduction by farm type/cluster obtained from Parminter (2018). The report focused on dairy farms in the Upper-Manawatū catchment, which represents about 41% of the milk production in Tararua. We use this share to pro rata our shock as the Tararua district is not disaggregated in our model.

Regarding dairy farms in the Coastal Rangitikei Catchment of the Rangitikei (part) and Manawatū districts (part), some data were not available. We used the figures in the report to design our scenario, but it will need to be refined when we get more information.

For the Horowhenua horticultural industry, we model a decrease in productivity required to meet the One Plan provisions, drawing on the analysis by Ford (2017). As we didn't have all the data available for the simulation, we mocked up a scenario and shocked land productivity so that it reflected a 58% decrease in profitability in the horticulture industry. This figure is most likely over-estimated, and we will refine this scenario when we get additional data.

To estimate the effects of the original Table 14. 2 targets and the revised Table 14.2 targets of the One Plan, we run two sets of separate simulations:

- In the first set of simulations we imposed a shock on productivity for the dairy industry in Tararua and Rangitikei, and horticulture in Horowhenua so that it reflected the profitability losses expected from meeting the nitrogen loss targets of the original Table 14.2.
- In the second set of simulations, we imposed a shock on the land productivity for the dairy industry in Tararua and Rangitikei so that it reflected the profitability losses expected from meeting the nitrogen loss targets of the revised Table 14.2. We have not run a simulation for horticulture in

Horowhenua for the revised Table 14.2 targets as no additional change is expected compared with the original Table 14.2.

B.6 Closure

As noted previously, in any CGE model, it is important to understand which factors have been allowed to vary and which remain fixed by assumption (also known as exogenous variables). The particular combination of fixed factors is known as the closure.

In Table 11, we list the main variables included in the closure in the modelling underlying this report.

- National employment is fixed but labour is completely mobile between industries and regions, and real wages adjusts. This is consistent with the idea that, both the labour force and the rate of employment are, in the long run, determined by mechanisms outside the model.
- Household and government expenditures move together to accommodate a fixed balance of trade as a share of GDP.
- Rates of return are exogenous and capital is mobile between industries and regions. This mobility can occur either in the form of machinery etc. being physically moved, or capital in one industry/region being allowed to depreciate without replacement while investment builds up the stock of another industry/region.
- Foreign currency prices of imports are naturally exogenous.
- Real government consumption is also exogenous.
- Other exogenous variables include rates of production tax, technological coefficients, national population, and national labour supply.

Table 11 Fixed elements of the CGE model

Exogenous variables
Taxes on production
Technological change
Government demand
Gross growth rate of capital
Gross rate of return on capital
Number of households
National population
National labour supply
Import prices, foreign currency
Foreign demand for New Zealand exports
Land use

Source: NZIER

Appendix C Additional results

Table 12 Indirect impacts on selected industries in the Rangitikei district

Percentage change

Industry	Type	Impacts (%)	
		Original Table 14.2	Revised Table 14.2
Other transports	Supplying industries	-1.82%	-0.83%
Utilities		-0.31%	-0.13%
Motor vehicle		-0.88%	-0.40%
Road, rail transport		-0.68%	-0.30%
Wholesale		-0.77%	-0.35%
Agriculture services		-0.74%	-0.25%
Dairy product manufacturing	Downstream industry	-39.42%	-20.25%
Retail	Household expenditure	-0.22%	-0.01%
Real estate		-0.60%	-0.27%
Sheep and beef	Competing industries	0.59%	0.25%
Meat product manufacturing		0.19%	0.08%
Mining		0.20%	0.09%
Forestry		0.12%	0.05%
Poultry and other livestock		1.37%	0.64%
Fruit, vegetable and other food products		0.05%	0.07%
Horticulture		2.94%	0.03%
Seafood products		2.53%	0.04%

Source: NZIER, Results from CGE modelling

Table 13 Indirect impacts on selected industries in the Horowhenua district

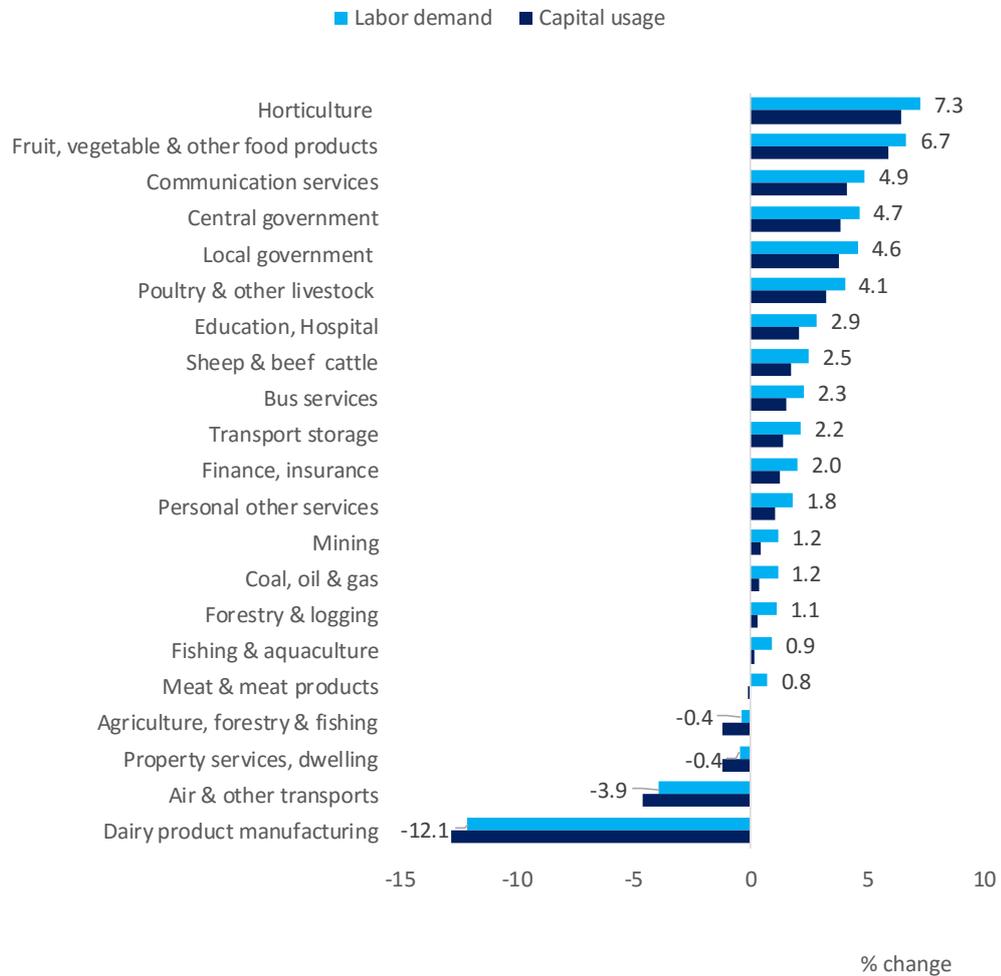
Percentage change

Industry	Type	Impacts (%) with the Original Table 14.2
Other transports	Supplying industries	-1.90%
Utilities		4.00%
Motor vehicle		-2.20%
Road, rail transport		-0.53%
Wholesale		-1.74%
Fertilisers		-1.12%
Agriculture services		3.02%
Fruit, vegetable and other food products	downstream industries	-3.70%
Retail	Household expenditure	-2.32%
Real estate		-0.71%
Electricity generation	Competing industries	0.33%
Sheep and beef		2.37%
Dairy cattle		0.67%
Dairy product manufacturing		0.57%
Poultry		4.52%
Forestry		0.18%
Paper product manufacturing		0.45%
Clothing		2.77%

Source: NZIER, Results from CGE modelling

Figure 8 Impacts of the original Table 14.2 targets on primary factors for selected industries in the Tararua district

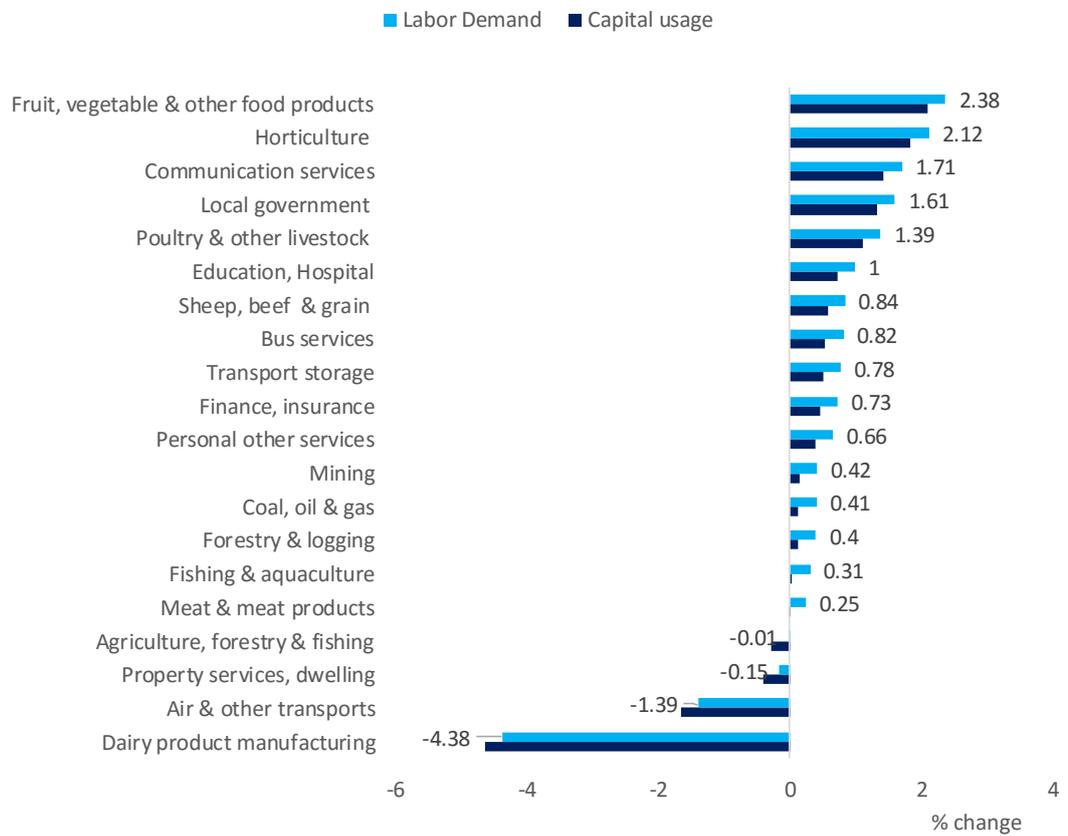
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 9 Impacts of the revised Table 14.2 targets on primary factors for selected industries in the Tararua district

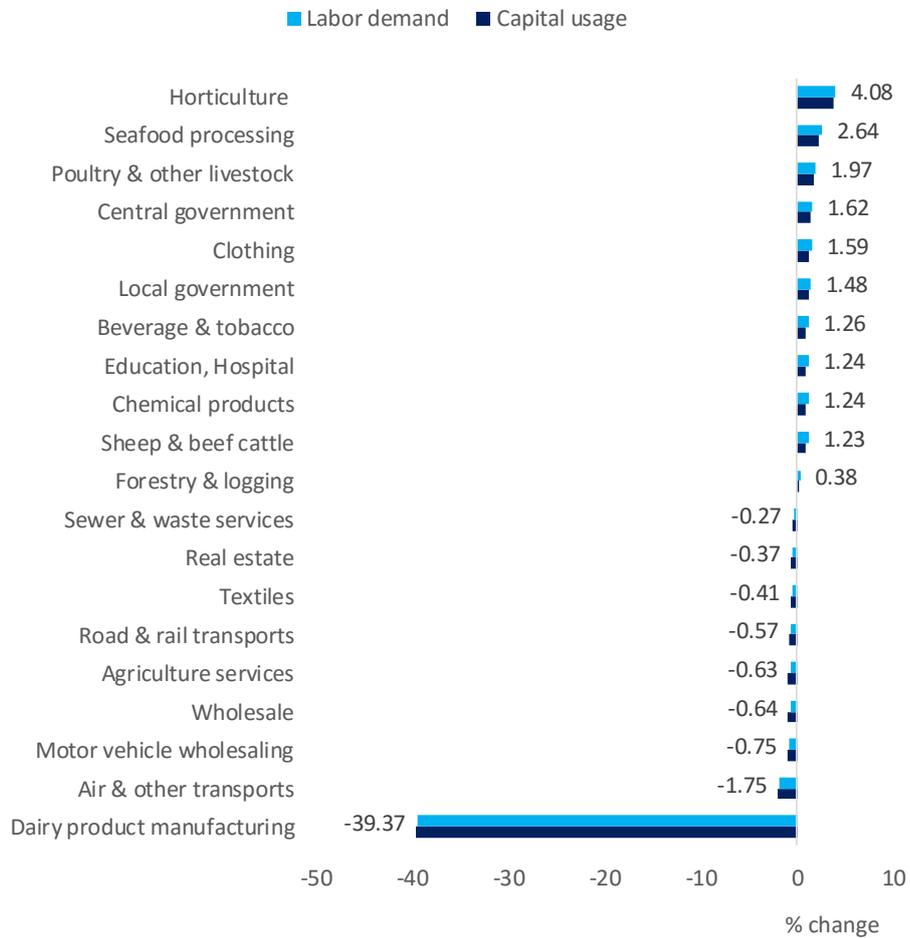
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 10 Impacts of the original Table 14.2 targets on primary factors for selected industries in Rangitikei

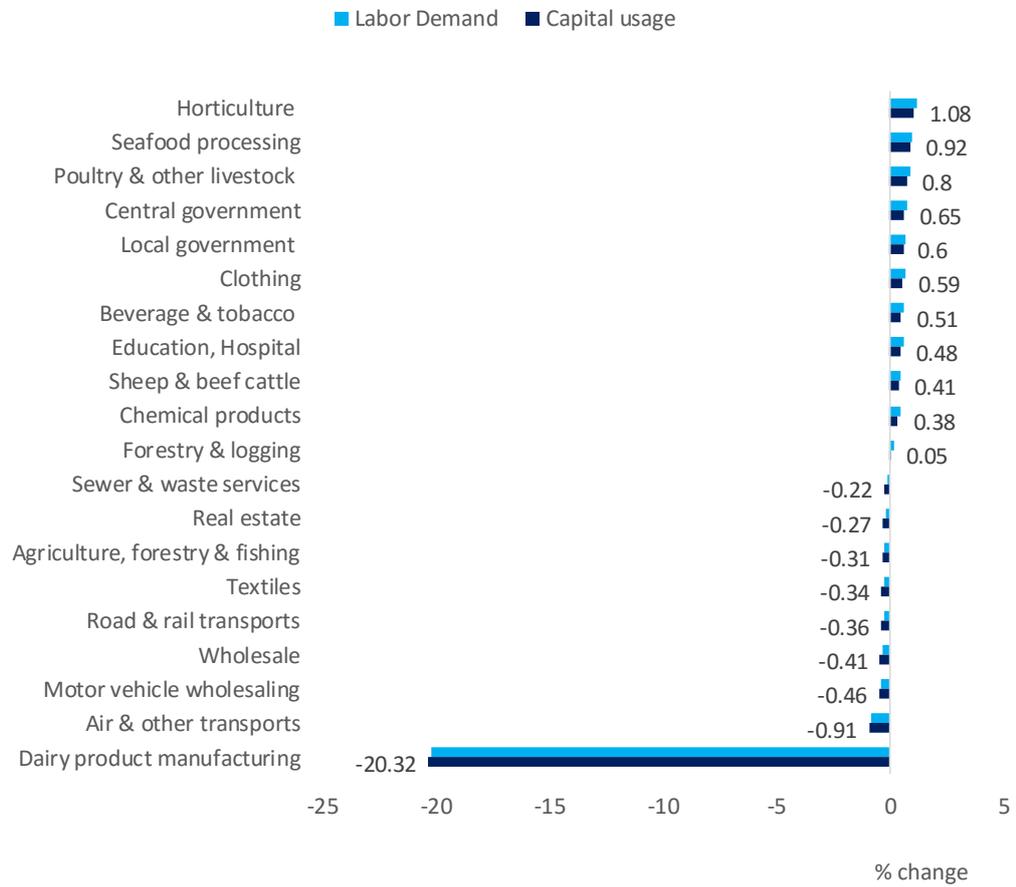
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 11 Impacts of the revised Table 14.2 targets on primary factors for selected industries in Rangitikei

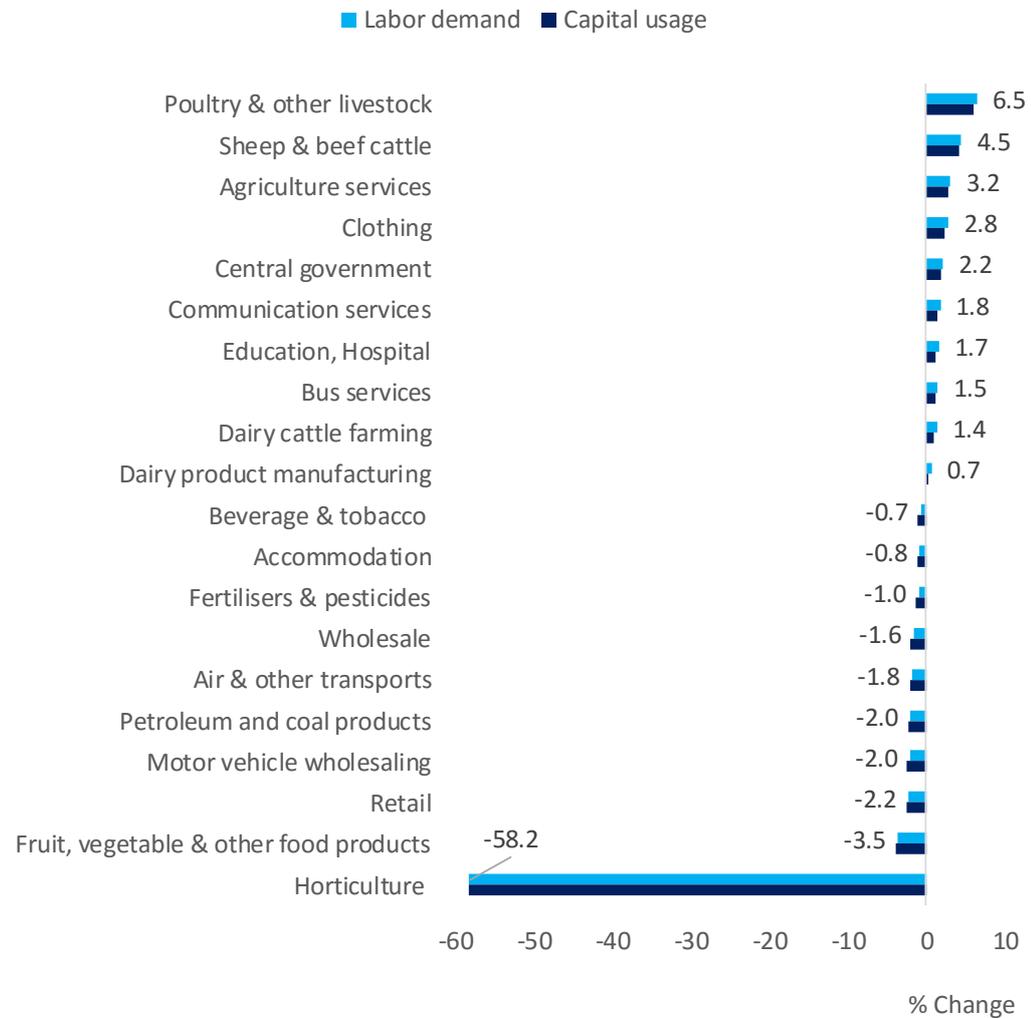
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 12 Impacts of the original Table 14.2 targets on primary factors for selected industries in Horowhenua

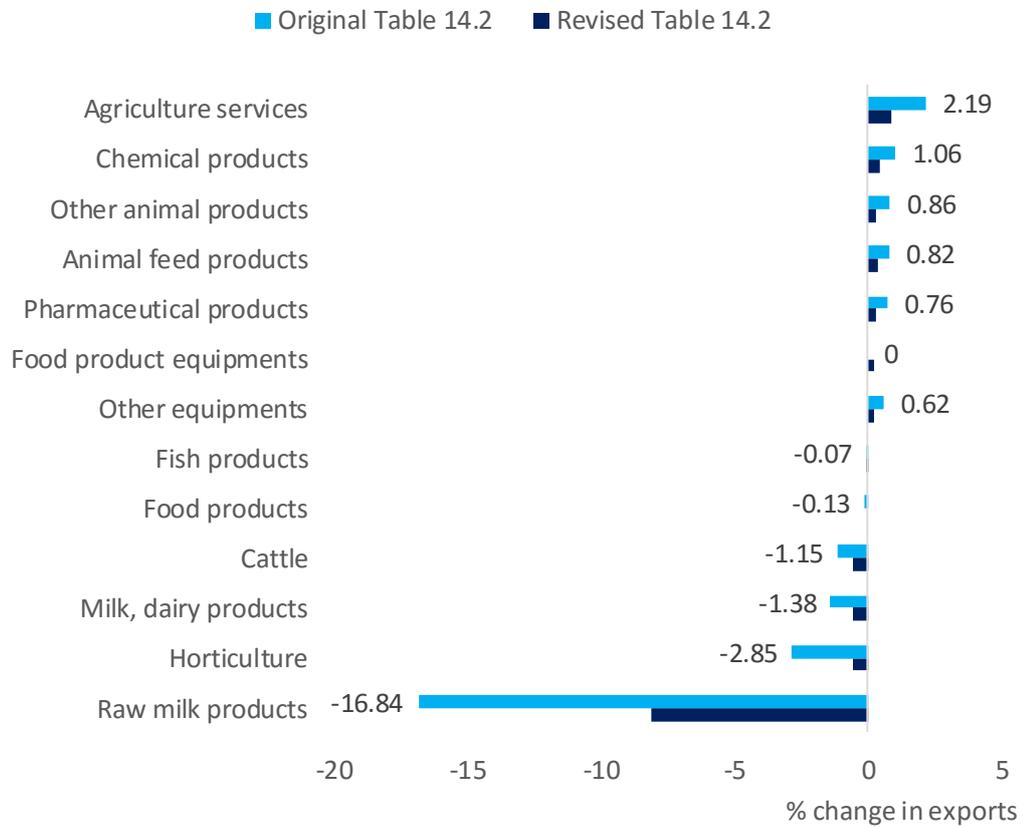
Percentage change of primary factor demands



Source: NZIER, Results from CGE modelling

Figure 13 Trade effects on selected products in Rangitikei

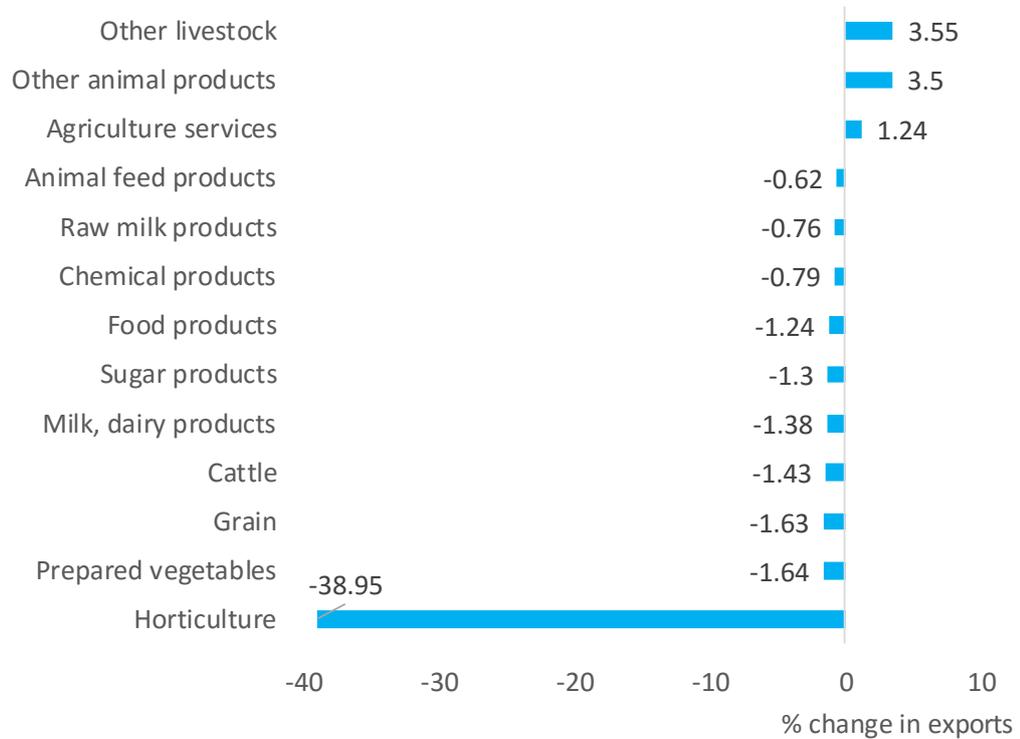
Percentage change in export demands



Source: NZIER, Results from CGE modelling

Figure 14 Trade effects on selected products in Horowhenua with the original Table 14.2 targets

Percentage change in export demands



Source: NZIER, Results from CGE modelling