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Report referred to in Generic Opening Submissions on behalf of Chris Insley
Analysis of MfE ETS forestry options for Climate Forestry Association (30 August 2023) J Ballingall, Sense Partners

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Analysis of MfE ETS forestry options

Final report to Climate Forestry Association

30 August 2023

SENSE PARTNERS

DATA LOGIC ACTION

Key points

The discussion document on reforming the ETS is based on questionable analysis

- The alleged problem definition on which the agencies' discussion document ('Consultation')[1] is based is that "current market settings are likely to lead to NZU supply exceeding demand from emitters", which will lead to weaker incentives for gross emissions reductions as the NZU price will be very low.
- The evidence base for this assertion is far from compelling and is shaped around two fundamentally flawed NZU demand/supply scenarios.
- The **first supply scenario is implausible**.
    - It shows a very large supply of forestry units and implies, given assumed demand, that ETS prices would collapse.
    - This ignores the dynamics of lower expected prices on planting. If prices are expected to collapse, then planting would slow.
    - Even the Consultation acknowledges that long run excess supply is "highly likely to be unsustainable", leaving one wondering why the excess supply scenario was included in the first place and why the Consultation still concludes that NZU supply will exceed demand.
- The **second supply scenario is inconsistent** with existing policy settings.
    - It is assumed that ETS settings will not change even as prices decline due to an assumption of declining demand for units and falling supply of forestry removals that place New Zealand's net zero emissions target at risk.
    - But the ETS functions only as a mechanism for delivering on long term targets. Its settings would necessarily have to be adjusted if these targets were at risk of being missed.
    - Most fundamentally, the ETS cannot be de-linked from forestry removals. As long as the government's emissions reduction targets include removals – i.e. net emissions – the amount of removals will affect ETS caps and therefore ETS prices.
- Further, the demand side projections rely heavily on the Climate Change Commission's 'demonstration path' estimates. The modelling behind these estimates makes strong assumptions about behaviour change, assumes several large emitting sectors never change their output, that non-price interventions are essentially costless, and that land use change and forestry do not respond to emissions prices.

[1] Ministry for the Environment, Ministry for Primary Industries, and Ministry of Business, Innovation & Employment. 2023. Review of the New Zealand Emissions Trading Scheme. Wellington: Ministry for the Environment.

- The demand analysis entirely ignores demand for forestry credits from rapidly growing voluntary carbon markets and from longer term links between the New Zealand ETS and other compliance markets.

Officials' modelling of the forestry sector is unreliable and has yet to incorporate important aspects of the industry

- Modelling released part-way through the consultation process is a starting point for understanding the relationships between carbon prices, afforestation and removals, and meeting New Zealand's emissions targets.
- But it does not yet consider forestry owners' expectations about ETS prices and how they might act on them, the role of policy uncertainty on investment, diminishing returns to afforestation in the longer term as establishment costs rise, or the demand response to changes in the ETS price.
- It is also based on the recent past, where economic and policy conditions have been particularly favourable for afforestation. These conditions are not representative of the likely medium- to long-term outlook.
- The modelled relationship between ETS prices and afforestation does not perform at all well statistically.
- Despite the modellers' acknowledgements that their simplistic analysis would be inappropriate for inferring with any confidence future forestry investment patterns, their results were nonetheless used for precisely this purpose.

The options proposed are poorly designed solutions to a poorly-specified problem

- There is precious little detail in the Consultation about how the four options presented would operate in practice. However, the broad 'goldilocks' aim is "balancing the need for firms to transition to low emissions practices with a need to keep overall costs to the economy manageable".
- Quite how officials would design precisely the right incentive to achieve just the right amount of NZUs from forestry is unclear. And there is no consideration of the costs of policy-induced disruption and uncertainty, such as the deterrent effects on afforestation.
- Indeed, there is no quantified analysis of the four options put forward for consultation.
- It is certainly challenging to attempt to quantify the potential economic costs and benefits based on the vague descriptions provided. However, to fill the evidential void we have put some parameters around the broad intent of the options and designed a range of scenarios which we have run through our MDG-NZ dynamic computable general equilibrium model of the New Zealand economy.[2]

[2] MDG-NZ explores how the entire economy adjusts out to 2050 to changes in policy settings or shifts in the economic environment. It captures the interlinkages between industries, households, government, workers, investors, etc and the emissions associated with production and consumption. We use a top-down regional version of the model that projects the output and emissions activities of 79 sectors in 16 regions.

We model the economic impacts of introducing differential pricing for NZUs for foresters and emitters

- In essence, the four options all seek to reduce the role of exotic forestry in meeting New Zealand's domestic and international emissions targets, and thus increase the need for gross emissions reductions. The mechanisms vary across the four options but the conceptual intent is common.
- We model this intent by introducing differential pricing for NZUs, whereby foresters receive 50% of the prevailing NZU price (which is determined by the model) and emitters pay a premium of between 0% and 200% of the NZU price (Scenarios 2-6).[3]
- We use afforestation projections from the Climate Forestry Association, which take into account (but which are not endogenously determined by) potential NZU price paths under the scenarios.
- In each scenario, we set the emissions pathway to meet our net zero target for long-lived gasses and a 24% decrease in methane from 2017 levels by 2050. The NZU price then adjusts to clear the emissions market.
- We compare the economic impacts of these scenarios against a baseline that reflects the CCC's Current Policy Reference scenario. We also compare them against a scenario in which our net zero target is reached under current ETS policy settings (Scenario 1).

Summary of headline results

TABLE 1 SUMMARY OF HEADLINE RESULTS, 2040

Change relative to Scenario 1 in…	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Real GDP, $m	-$719	-$1,166	-$1,587	-$1,983	-$2,363
Real household spending, $m	$91	$16	-$66	-$151	-$237
Real investment, $m	-$565	-$816	-$1,044	-$1,253	-$1,449
Real exports, $m	-$542	-$784	-$1,003	-$1,204	-$1,391
FTE jobs	- 2,898	- 3,950	- 4,914	- 5,790	- 6,622
Real wages, %	-0.84	-1.17	-1.47	-1.75	-2.00
NZU price faced by emitters, $	$14	$20	$26	$32	$37
Fiscal balance, $m	-$278	-$391	-$494	-$589	-$677

SOURCE: MDG-NZ MODELLING

[3] The 50% cut in price for foresters is based on the discussion document's references to a '2-for-1' type arrangement. The premium that emitters might pay is not discussed anywhere, so our range is necessarily illustrative. These scenarios are not forecasts of what we think *will* happen; they are indicative of what might happen, in lieu of any more detail from officials. We are happy to revise our scenarios should further policy design detail become available.

TABLE 2 SUMMARY OF HEADLINE RESULTS, 2050

Change relative to Scenario 1 in...	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6
Real GDP, $m	-$6,136	-$7,256	-$8,400	-$9,591	-$10,860
Real household spending, $m	-$1,424	-$1,702	-$2,031	-$2,400	-$2,812
Real investment, $m	-$3,102	-$3,674	-$4,222	-$4,772	-$5,343
Real exports, $m	-$3,121	-$3,679	-$4,211	-$4,738	-$5,274
FTE jobs	-5,724	-7,279	-8,509	-9,659	-10,856
Real wages, %	-3.10	-3.72	-4.29	-4.84	-5.40
NZU price faced by emitters, $	$159	$185	$210	$235	$262
Fiscal balance, $m	-$2,575	-$3,014	-$3,435	-$3,854	-$4,288

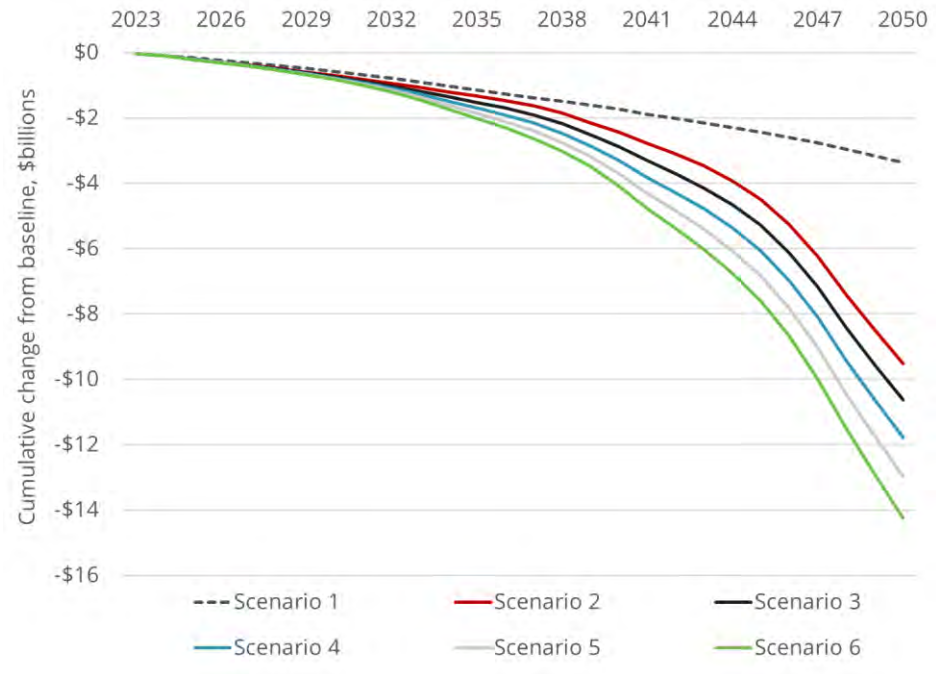
SOURCE: MDG-NZ MODELLING

Amending the ETS to reduce the role of exotic forestry NZUs will materially increase the costs of getting to net zero by 2050

- We estimate the GDP costs of getting to net zero under our differential pricing scenarios could be **3 to 4 times the cost under current ETS settings**.
- Under existing ETS forestry settings, we estimate getting to net zero by 2050 would lead to the economy being 0.5% smaller than baseline.[4] In our differential pricing scenarios, that GDP cost rises to between 1.4% and 2.1% by 2050.
- The additional GDP impacts stem from emitters facing a higher cost of carbon when forestry is priced to be less attractive. More of the hard work in getting to net zero comes through gross emissions reductions, which are more expensive than forestry removals.
- Higher emissions costs decrease the international competitiveness of our export sector. The real value of exports in 2050 could drop by between $4.9 billion and $7.0 billion below baseline in the differential pricing scenarios, compared to $1.8 billion if we move to net zero under current ETS forestry settings.
- In dollar terms (see Figure 1 overleaf), the GDP cost of getting to net zero increases from $3.4 billion by 2050 under current settings (the 'Scenario 1' dashed line) to between $9.5 billion to $14.2 billion by 2050 in our differential pricing scenarios.

[4] This is around half the cost the CCC (2021) estimated, primarily because our model incorporates endogenous technological change to a higher carbon price. We also impose fewer constraints on industry output, which allows a more flexible and efficient adjustment of output across sectors.

FIGURE 1 CUMULATIVE CHANGE IN REAL GDP FROM BASELINE, $ BILLIONS



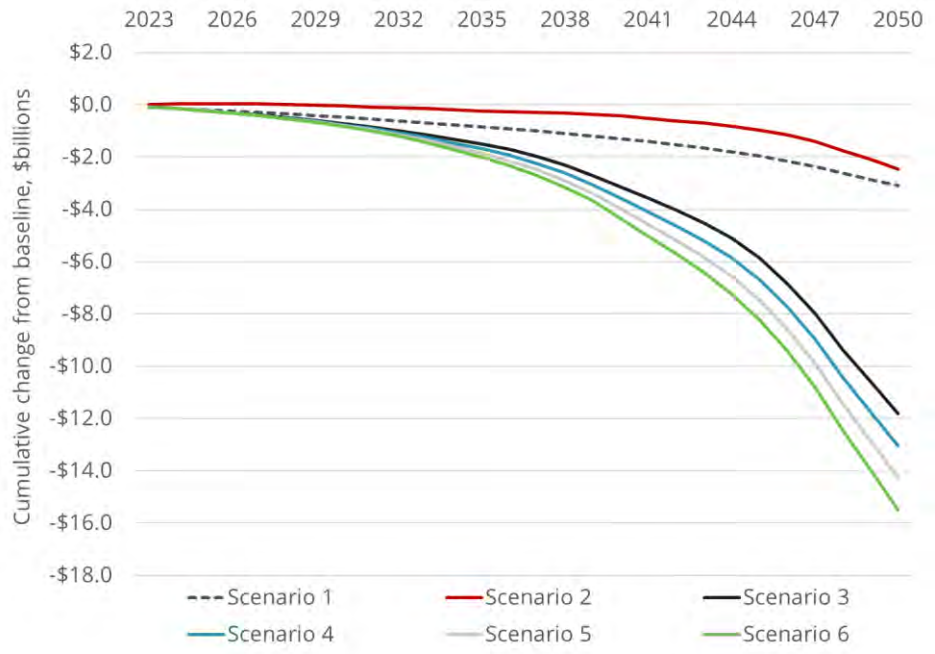
SOURCE: MDG-NZ MODELLING

- Under these scenarios, the effective real carbon price faced by emitters increases from current levels to between $75 and $98 by 2040 and between $269 to $371 by 2050. This compares to around $61 and $98 for the same years under current ETS policy settings.

The fiscal balance would deteriorate as tax revenue declines, leading to more government debt for future generations to repay

- Under all the scenarios where forestry plays a smaller role in meeting our emissions targets, government's tax take declines markedly (Figure 2).
- This is driven mainly by a decline in personal income taxes (which accounts for around 80% of the drop) as employment softens and real wages fall.
- The decline in tax revenue sees the fiscal deficit worsen by between $3.7 billion and $5.4 billion below baseline by 2050, compared to $1.2 billion if we meet our net zero target under existing ETS settings.
- Additional government borrowing is required to fund spending commitments, including an extra $690 million that will need to be directed to purchases of offshore units to meet our NDCs in 2030, 2040 and 2050 (Scenarios 2-6 relative to Scenario 1).
- This increases the tax burden on future generations of meeting our net zero targets as the additional debt needs to be serviced.

FIGURE 2 CUMULATIVE CHANGE IN TAX REVENUE FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

Households could be 2.5 to 3.8 times worse off by 2050 as employment and real wages fall

- As the economy contracts relative to the baseline, the demand for labour decreases. Aggregate employment could fall by between 0.36% and 0.51% below baseline by 2050 in the differential pricing scenarios. This compares to just 0.05% in the current ETS setting scenario.[5]
- Relative to Scenario 1, these changes equate to:
    - around 2,900 to 6,600 fewer FTEs by 2040
    - around 5,700 to 10,900 fewer FTEs by 2050.
- Average real wages across the economy could be between 4.6% and 6.9% lower than baseline by 2050 if forestry removals play a smaller role in meeting our net zero targets.
- Fewer jobs and lower real wages (plus a depreciation of the real exchange rate) lead to households spending between $2.5 billion and $3.8 billion less than baseline by 2050 under these differential pricing scenarios, compared to a drop of $1.0 billion if existing ETS forestry settings are maintained.
- That is, **households are 2.5 to 3.8 times worse off** than under current ETS settings on the path to net zero.

[5] MDG-NZ has a 'sticky real wages' dynamic labour market adjustment mechanism. This means labour demand effects are seen through employment changes in the short run. Over the longer term employment returns to baseline levels and weaker labour demand is seen through real wage decreases.

- On a per household basis, average spending will be around $1,100 to $1600 lower than the baseline by 2050.

Lower income households will feel the pain of higher prices most severely

- In addition, a higher carbon price pushes up the cost of everyday items such as electricity and fuel.
    - We estimate light vehicle (i.e. passenger and light commercial) fuel prices could rise by between 7.4% and 11.0% above baseline by 2050, compared to 2.4% in the current ETS settings scenario.
    - Electricity prices could rise by between 7.4% and 9.1% above baseline by 2050, compared to 3.2% in the current ETS settings scenario.
    - In today's money these price increases amount to an average cost of $230 to $380 per year per household from the proposed policy changes.[6]
- The Consultation's options are also regressive in terms of their impacts on household spending. Lower income households, including superannuitants, are worse off because a larger share of their income is spent on essential goods and services whose prices rise (e.g. electricity, fuel).
- Impacts on low income households are 40% worse than for high income households (a 1.9% real expenditure decline in the lowest income quintile against a 1.3% real income decline in the highest income quintile).

The slowing economy would affect lower-skilled workers the most

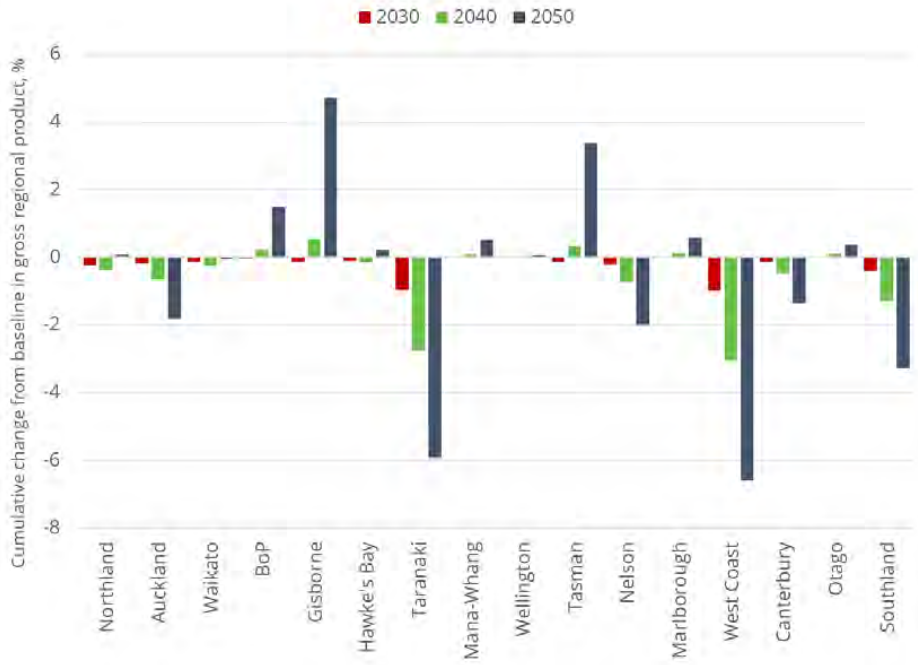
- We show the potential employment impacts for lower-skilled roles (e.g. machinery drivers and operators; technicians and trades workers; labourers) are worse than those for higher-skilled roles.
- Under the differential pricing scenarios, we estimate, relative to a scenario where net zero is reached under current ETS settings, there could be:
    - between around 4,900 and 7,950 fewer FTE jobs for machinery operators and drivers by 2050
    - between 2,000 and 3,000 fewer FTE jobs for technicians and trades workers by 2050.
- This reflects the greater share of such workers in the sectors that are hardest hit by a higher carbon price, such as farming, mining, primary processing, fishing and seafood processing, metal and minerals manufacturing and air transport.

[6] This 'today's money' estimate reflects current average household expenditure in 2023, projected household expenditure shares for electricity and vehicle fuels in the baseline, and price increases over and above the price changes in the scenario with current ETS current settings.

Regional impacts vary, with the West Coast, Taranaki, Southland and Nelson hardest hit

- Regions with a high reliance on the declining farming, extractive industries and heavy manufacturing sectors – such as the West Coast, Taranaki and Southland – suffer most in our differential pricing scenarios (see Figure 3 for Scenario 4; other scenarios have a similar pattern).

FIGURE 3 CUMULATIVE CHANGE FROM BASELINE IN GROSS REGIONAL PRODUCT, %, SCENARIO 4



SOURCE: MDG-NZ MODELLING

- Nelson's GDP falls below the baseline primarily due to its shrinking fishing and aquaculture and seafood processing sectors.
- Professional services-focused regions such as Wellington and Auckland are less hard hit, as they are less emissions intensive. They also benefit, in relative terms, from lower real wages, as they tend to be relatively labour intensive.
- Regions that rely on exports – such as Marlborough with its dominant wine sector – get a small fillip from a depreciation of the real exchange rate.
- Those regions with a large forestry and logging sector – such as Northland, Bay of Plenty, Gisborne and Tasman – tend to contract between 2025 and the late 2030s as the 50% cut on the prevailing NZU price decreases profitability and hence investment and output.

  Later in the projection period the prevailing NZU price rises so strongly that even a 50% discount on it represents a higher return than in the baseline. This sees forestry expand towards 2050. Greater availability of logs also benefits regions with strong wood processing sectors.

Impacts on the economy Māori are significant

- We estimate Māori GDP could be between $280 million to $580 million lower in 2040, relative to the scenario where we reach net zero under existing ETS settings. In 2050, these losses grow to $560 million to $1.14 billion.[7]
- By 2050, Māori employment could be between 550 and 4,600 lower than in the scenario where we reach net zero under existing ETS settings, as the contraction of the wider economy and rapid growth of the forestry sector partly offset each other.
- The largest Māori job losses come in the forestry and logging, construction, primary sector support services, air transport and chemicals sectors.
- Māori households' expenditure is expected to decline by 1.3% on average (-$1,240 in today's money)[8], lower than the 1.5% average decline for all households. This is largely because Māori households are, based on current data, younger than the average household with lower expenditure shares for utilities (whose prices rise based on our modelling) and higher expenditure shares on rents (which are expected to decline in relative price).
- Given the negative impacts on Māori, lower income households, lower skilled workers and several regional economies, the Consultation's options will present a challenge to a 'Just Transition' towards a lower emissions future.

We recommend officials revisit their over-supply analysis

- Imposing material costs on the economy, its regions, workers and Māori based on a flimsy problem definition that doesn't stand up to real-world scrutiny would be highly concerning.
- We recommend officials press pause on this consultation while they:

  (i) Re-examine the forestry over-supply 'problem' with more sophisticated, realistic and accurate models.

  (ii) Empirically analyse the macroeconomic, industry, regional, household and Māori impacts of any alternative ETS settings for forestry.

[7] These figures are calculated by pro-rating our CGE modelling results through Māori employment by industry by region matrices. Given the paucity of official Māori economic data, especially at the level of granularity we require, these estimates should be treated as indicative.
[8] Dollar value based on recent estimates of average disposable income, from the Stats NZ HES income survey, for households in which one household member identifies as Māori.

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1. Purpose and scope

We analyse ETS policy options qualitatively and quantitatively

Climate Forestry Association (CFA) has asked Sense Partners to provide independent economic analysis of the 'Te Arotake Mahere Hokohoko Tukunga: Review of the New Zealand Emissions Trading Scheme' ("Consultation").[9]

The basis for suggesting potential changes to the ETS is government's modelling of the supply and demand for NZUs which suggests, over time, the supply of NZUs – largely from forestry removals – will outstrip demand. This in turn will lead to the NZU price falling, which "would undermine the ability of the NZ ETS to maintain a strong and stable emissions price that drives gross emissions reductions and incentivises removals" (Consultation, p.28).

We first examine the conceptual validity of the government seeking to change the balance between exotic forestry removals and gross reductions in achieving both its Nationally Determined Contribution and domestic net zero targets. We review the government's modelling of NZU demand and supply and interrogate its logic.

We then use an economy-wide model (MDG-NZ)[10] to compare the economic impacts of getting to net zero for long-lived gasses by 2050 under current ETS policy settings relative to hitting the same target with alternative ETS settings related to exotic forestry.

The alternative settings we examine are based on the descriptions suggested in Options 3 and 4 of the Consultation, although for the purposes of modelling we have had to assume additional details because these have not been provided in the Consultation.

Given the lack of detail in the Consultation's options, the economy-wide modelling is necessarily indicative

The dynamic Computable General Equilibrium (CGE) modelling carried out using MDG-NZ seeks to provide insights into the following question:

> *Given reasonable assumptions regarding future gross emissions and sequestration, how might Options 3 and 4 in the Consultation affect the potential macroeconomic costs and distributional impacts of getting to net zero by 2050?*

We use an augmented version of the Climate Change Commission's (CCC) Current Policy Reference (CPR) scenario as our baseline scenario. We present results out to 2050 at the national level and for the economies of New Zealand's 16 Regional Councils, for 79 sectors.

Other than some examples, the Consultation does not provide any detail on how exotic forestry removals might be treated under its Options 3 and 4. In that vacuum, we have been

[9] Ministry for the Environment, Ministry for Primary Industries, and Ministry of Business, Innovation & Employment. 2023. *Review of the New Zealand Emissions Trading Scheme: DD.* Wellington: Ministry for the Environment.

[10] We have used versions for this model for MBIE and MoT to inform policy advice related to biofuels and accelerated depreciation for emissions-efficient capital.

forced to make assumptions. The assumptions we have made for modelling purposes are consistent – we think – with the broad thrust of the options.

We are happy to revise our modelling assumptions should more policy detail become available.

More broadly, any economic and climate policy modelling exercise going out 25+ years requires making a range of assumptions about the pace of technological change, fuel sources, behavioural responses to emissions prices, consumer preferences, etc.[11]

All these issues and assumptions can be debated and explored in more detail with more time and resources – and this debate is crucial when we are considering such a material change in New Zealand's climate policy settings. However, in the very limited period available for responding to the Consultation, they are not our priority here.

Instead we seek to fill a void in the evidence base surrounding the economic implications of reducing the role of forestry removals in meeting New Zealand's emissions targets.

[11] See NZIER and Infometrics (2009) for an overview of strengths and limitations of CGE modelling more broadly.

2. Review of analysis presented by officials

The executive summary of the Consultation notes:

> *The review aims to clarify the impact that the NZ ETS will have under its current settings and identify the changes that may be needed.* (emphasis added)

But the analysis in the document does not clarify the impacts of the ETS under current settings.

The analysis has the hallmarks of being hurried, with work still to be done to clarify the potential impacts of forestry on the ETS and on the achievement of New Zealand's domestic and international emissions targets.

It is, in our view, inappropriate for the consultation to leap to options, when its analysis of the status quo is incomplete.

A reminder of New Zealand's emissions targets

New Zealand's international and domestic emissions targets are both based on net emissions, rather than gross emissions.

Our NDC is a 50% reduction of net emissions below our 2005 gross level by 2030.

The Climate Change Response (Zero Carbon) Amendment Act 2019 legislates our domestic emissions to be:

(i) Net zero emissions of all emissions other than biogenic methane by 2050.

(ii) A 24 to 47% reduction of biogenic methane emissions by 2050, relative to 2017 levels, including a 10% reduction by 2030.

Neither the international nor domestic target specifies the gross CO2 emissions reductions New Zealand might want to make.

The NDC can be met through a combination of gross emissions reductions, domestic forestry removals and the purchase of offshore units. At this stage, the government does not plan to use offshore units to meet domestic targets.

The review finds there will be "excess supply" of units

The analysis of ETS market dynamics was based on a model of supply and demand for NZUs. However the Consultation contains almost no information about that modelling, other than high level results in the form of charts with no supporting data or assumptions.

Two scenarios are presented and it is concluded that "current market settings are likely to lead to NZU supply exceeding demand from emitters" (p.28).

The analysis that is presented assumes that:

- ETS unit settings do not change
- There is a long run decline in emissions in ETS sectors, regardless of policy

- Non-price policies cause a substantial change in emissions in ETS sectors
- People will invest in forests and register in the ETS even if there is a collapse in ETS prices
- There will be zero additional sources of demand over 28 years
- Every single hectare of planting directly and inevitably translates into additional ETS supply and
- Planting will reach record levels and sustain them for 25 years.

Will forestry investors really make systematic errors?

The first scenario presented in the Consultation (Figure 4, p.25) shows a very large supply of NZUs from forestry. It implies, given assumed demand, that ETS prices would collapse.

Investors are expected to plant forests, in anticipation of earning revenue from NZUs, only to discover that their NZUs will be worthless.

We are expected to believe that this collapse in prices will not be known to investors, even though it is already known to officials. We submit that assuming your research subjects are ignorant and that you know more than them is bad practice. At a minimum, modellers should assume that what is known to them is also known to the people inside their models.[12]

If scenarios are implausible, why have they been published?

The consultation paper acknowledges that long run excess supply is "highly likely to be unsustainable". It suggests that a more likely scenario is that supply would fall, alongside an assumed decline in demand.

Broadly speaking, that is a more reasonable assessment; leaving one wondering why the excess supply scenario was included in the first place and why the consultation still concludes that NZU supply will exceed demand.

Even the more plausible scenario is not plausible

The more plausible scenario is still not plausible because it is inconsistent with existing policy settings.

In this scenario it is assumed that ETS settings will not change even as prices decline due to, an assumption of, declining demand for units and falling amounts of forestry removals that place New Zealand's net zero emissions target at risk. But ETS unit limits and price control settings are reconsidered annually taking account of emissions budgets and expected reductions in net emissions.

Long run supply and demand dynamics need to include the policy responses that are baked into legislated and regulatory processes. This is essential because the ETS functions only as a

[12] This is a long-established critique of modelling that assumes that people do not anticipate policy changes and that models calibrated to a past policy regimes can be useful for understanding behaviour under new policy regimes. In economics it is known as the Lucas Critique.

mechanism for delivering on long term targets. Furthermore, the existence of these long run targets has direct implications for the operation of the ETS.

Removals cannot be "de-linked" from the ETS

The idea that government can de-link forestry removals and ETS sector emissions reductions is fallacious.

As long as the government's emissions reduction targets include removals – i.e. net emissions – the amount of removals will affect ETS caps and therefore ETS prices.

If the government were to exclude removals from the ETS, and instead used other policies to encourage the 'right' amount of sequestration, changes in the amount of removals would still affect the ETS and ETS prices – by virtue of emissions budget setting process.

The big difference would be that the budget setting process is coarser and slower to adapt.

What is the right "balance" between emissions reductions and removals and how would officials get there?

It is enticing, but a leap of faith, to assume that an administratively determined incentive for removals would be able to strike precisely the right incentive to achieve just the right amount of removals – the goldilocks level of removals that meets the amorphous criteria of "balancing the need for firms to transition to low emissions practices with a need to keep overall costs to the economy manageable".

More likely, a change in policy would deter investors from investing in forestry; at least for a number of years. And given the decades it takes for sequestration to occur, let alone the years of lead time required to execute afforestation, policy induced disruption could have serious long-term costs and benefits from meeting long term targets.

Part of the problem with the Consultation's analysis is that it does not consider these costs. It assumes, implicitly, that a 'right' ETS price exists and that that is all that matters. And it does not acknowledge either the costs or benefits of fiddling with the ETS, beyond 'getting the price right'.

This rather curious perspective follows directly from the government's response to the Climate Change Commission's advice (2021), Inaia Tonu Nei.

Regrettably, that advice also did not consider the full implications of its demonstration pathway. Rather, it advised what it thought was the correct composition of net emission reductions, while simultaneously specifying a carbon price track that aligned with getting to zero and never attempting to connect the two, at least not as far as forestry is concerned and even though forestry was an indispensable component of meeting New Zealand's climate targets.

Needless to say it is fiendishly difficult if not impossible to specify prices and quantities at the same time, but the Climate Commission has created a benchmark for climate policy planning that is now affecting expectations about the ETS.

Demonstration path demand is not good basis for analysis

MfE's analysis relies altogether too much on the Climate Change Commission's demonstration path. The demonstration path should not be taken at face value for setting policy on the ground, because it makes a lot of very strong assumptions about what can be done, at the service of proving what could be done:

- It makes strong assumptions about behaviour change
- It assumes, implicitly, that non-price policies are costless
- It assumes that several large emitting sectors have output that never changes
- It assumes substantial parts of the economy are unaffected by emissions prices, including land use change and forestry.

That is not to impugn the usefulness of the demonstration path and the value of its underlying analysis. But it is a shame that this analysis has come to be used as the primary reference point for what the future will look like and, most importantly, how successful non-price policies will be in reducing emissions.

This especially so for analysis of the ETS, where demand for units is only one side of the coin. The world might not proceed anything like predicted in the demonstration path. And that is very relevant for an assessment of the impacts of the ETS because the value of the ETS is to ensure a fixed amount of mitigation is achieved.

The predictable impact of having lots of costless non-price policies delivering emissions reductions in the demonstration path is that the ETS price will fall, other things being equal.

Whether or not we ought to be sad or glad about that depends on the cost effectiveness of the non-price policies. If they have made it easier (cheaper) to meet a target, we should be glad. If they have made it harder (more expensive) we should be sad.

These issues are of critical importance to assessing the effectiveness of climate policy in delivering on emission reduction targets. If it is the case that these impacts are more cost-effective, ought we do more of them? If they are not cost effective, should we do less of them and rely on the ETS more?

Surely these are systematically more important questions than targeting a particular emissions price because the demonstration path says so?

The tools are only now being developed and they need work

The policy modelling released part way through the consultation period, and a webinar discussing the modelling, suggest to us that some serious work has begun to consider the interrelationship between emissions pricing and forestry and emissions targets. This sort of analysis is overdue and most welcome, but the modelling is clearly in its infancy.

The premature nature of the analysis is suggested by the fact that the modelling, which appears to be intended to produce logically and internally consistent results, has not yet incorporated essential considerations such as:

- How market participants and forest owners form expectations about ETS prices and act on those expectations

- The role of market conditions on afforestation, including capital markets and commodity prices
- The impact of policy uncertainty on forestry investors and other market participants
- Diminishing returns to afforestation in the long run, due to rising costs of forest establishment
- The impact of emissions prices on demand for ETS units via
    - firms' activities and emissions intensities
    - long run effects of ETS prices on mass market demand
- Demand for removal units coming from outside of domestic ETS sectors including
    - voluntary carbon markets, projected to grow enormously in coming decades[13]
    - linking the NZ ETS to other markets internationally.

The modelling did not show any analysis of the impact of policy on afforestation and supply of NZUs from forestry

Officials explained that policy effects would be analysed in later work. However, we wonder how it is that the modelling could adequately address questions about status quo market dynamics if it did not at least attempt to analyse the effects the policy has recently had (or could have) on participants' expectations and foresters' willingness to invest.

The effect of policy changes on investors behaviour is key given the risk of what is referred to as hold-up – that is incentivising an investment and then pulling the rug out afterwards. This is otherwise known as a commitment problem. Needless to say that the existence of this problem impacts investor confidence and can spill over from affected sectors into other sectors.

The modelling did rely rather heavily on simplistic regression model results that summarised correlations between carbon prices and log prices and afforestation. Reliance on these models was acknowledged to be inappropriate for making inferences about future investment, but was used nonetheless.

The consultation paper itself has surprisingly little discussion of the modelling. Given that the modelling was released some weeks after the consultation paper, we do wonder if the modelling was not sufficiently well-developed for releasing when the consultation paper went to press.

The forestry part of the analysis is especially poor

The analysis uses a mixture of methods to predict future NZUs from forestry:

- MPI projections

[13] Voluntary carbon markets are larger than compliance markets and expected to grow five-fold by 2030.

- Assumed "endogenous" relationships between contemporaneous ETS prices and afforestation.

The main MPI afforestation projections used in the consultation Consultation are far too reliant on questionable assumptions to be useful for predicting future afforestation.

The projections are based not on fundamentals, but on extrapolations from recent activity and intentions surveys that existed in a policy context that has changed in profound ways and a market context that is ever evolving. For example, it was inevitable that the release of this consultation will create massive uncertainty for foresters which would translate directly into reduced planting commitments. Yet the government modelling of oversupply assumes that planting accelerates - reaching record levels and continuing at that level for 25 years.

Relevant influences on afforestation include:

- relative rates of return from other land uses
- costs of capital
- availability of resources including land, people, seedlings and finance
- government grants
- regulatory change and predictability, whether ETS settings or legislative and local regimes for resource management including land use.

Recent conditions are not reflective of a 'normal' environment for forestry and other land uses

As far as relative rates of return to land uses are concerned, it is worth bearing in mind that pastoral farming has been grappling with a highly unfavourable regulatory environment, from a commercial perspective.

Forest planting, on the other hand, has faced more favourable conditions, including a period of high carbon prices, stable climate policy outlook and government grant schemes. Combined with easy money conditions, it is no wonder that planting has increased.

None of these influences appear to have been taken account of in the calibration of projections to patterns of the recent past, whether the imposed afforestation scenarios or the 'endogenous' modelling of afforestation responses to changes in emissions prices.

The forestry model does not perform well in statistical terms

The modelled relationship between ETS prices and afforestation is especially weak. The prediction errors of the model are large. The model had a 75% mean absolute percentage error in the first three years of the projection and was out by 100% in the first forecast year.[14] That is not a result we would expect of a model that is "performing reasonably well", especially

[14] Manley, B., 2021. Afforestation Economic Modelling (Report to the Ministry for Primary Industries). Table 4 presents forecast performance for the years 2016 to 2021 and the author notes that the 'models are performing reasonably well' (p.6), though there is no explanation for that claim.

when you consider that those forecasts were based on known inputs: known log prices and known carbon prices.

Even if the model performed well on such forecast performance metrics, that is of no use for judging the forecasting performance of the model for cases when the inputs are not known. It would be more instructive to consider the forecast error bounds of the model. That is, quantified uncertainty that accounts for both model prediction error and uncertainty in the model inputs.

One might wonder if perhaps the model has improved predictive value at longer time frames. However, there is no evidence of that and indeed the author says there are problems predicting afforestation in future because the model's carbon price response is calibrated on limited data points (Manley, 2021 p.29)[15]

> *The data reflects carbon prices up to $34/NZU – the impact of the current much higher price (and growers' perceptions of the sustainability of that price) remains to be seen, hence the model's predictive ability is uncertain.*

More generally, the model in its current form does not and cannot identify the size of the effect of carbon prices on afforestation. This is because it excludes relevant predictive information – such as government grants or variation in labour costs, finance terms and non-labour planting costs – which will be conflated in carbon price and log price effects.[16]

[15] An earlier 2018 article similarly cautioned that "Given the limited empirical information to date on the impact of carbon price on afforestation, the model should be regarded as provisional and indicative only. In particular, estimating the impact of carbon prices above $20/NZU involves extrapolation beyond the range of available data" (Manley, 2018 p.119).

[16] It also fails to provide standard statistical justifications for the methods used and uses unorthodox statistical methods to justify what has been done. For example, the modelling papers (Manley, 2021; Manley 2018) do not explain how standard estimation problems when using time series data have been dealt with. The papers also use highly unusual and ad hoc model selection methods, namely selecting lags on the basis on maximising in-sample model explanatory power (R-squared). When compared to more fundamental identification problems, these criticisms are not fatal, but they certainly undermine confidence in the findings.

3. Economy-wide modelling approach

3.1. Overview of MDG-NZ CGE model

Origin of MDG-NZ

MDG-NZ is a highly advanced and flexible dynamic Computable General Equilibrium (CGE) model. It was built specifically for Sense Partners in 2019 by Dr Ashley Winston of Phylleos Inc. in Washington, D.C.

The New Zealand CGE modelling suite is built on the foundation of the pathbreaking and proven US MDG model. Versions of the MDG modelling framework have informed key policy reform and other economic matters in dozens of countries, including advising The White House on US biofuels and other energy reform issues.

We have used MDG-NZ for several New Zealand clients including MBIE, MoT, KiwiRail, The Treasury, Auckland Airport, and a group of Economic Development Agencies.

MDG-NZ explores how the entire economy adjusts over time to changes in policy settings or shifts in the economic environment. It captures the interlinkages between industries, households, government, workers, investors, etc ('economic agents') and the emissions associated with production and consumption.

Key features

MDG-NZ is a Monash-style recursive dynamic model representing the New Zealand economy and its regions at a highly detailed level, comprising 140 industries and 220 goods and services based on (but extended from) the latest official input-output tables from StatsNZ.

Core dynamic features of MDG-NZ include 'sticky wages' labour market adjustment, capital accumulation based on expected rates of return, the accumulation of net foreign liabilities to fund current account deficits, and public sector debt that accounts for fiscal deficits over time.

Our regional database comprises up to 16 regions, with each regional economy consisting of the same 140 industries, producing 220 goods or services. For this project, we use a top-down version of the regional model to apportion the national-level impacts of the scenarios across regions.[17]

In the interests of reducing computational time for solving the model, we have aggregated and diagonalised the database in this project to 79 single-product sectors (see Appendix A).

[17] We also have a bottom-up version of the regional model, whereby regions are linked through trade in intermediate and final goods and services, margins and movements of mobile factors of production. This model is better suited for exploring region-specific shocks, as opposed to the national-level policy scenarios in this project.

The greenhouse gas emissions associated with each sector's activities, and those of end users such as households, are also incorporated into our database. The database incorporates 37 types of emitting activities.[18]

For more details on MDG-NZ, see Appendix B.

Modelling process

We first project the economy and emissions each year out to 2050, drawing on official Treasury forecasts and emissions estimates from MfE and the CCC. We draw on forestry sequestration estimates from CFA. This forms our baseline scenario (see section 3.2.1).

We then 'shock' the model from this baseline by changing key parameters to generate a range of counterfactual or 'policy' scenarios, described below in section 3.2.2.

In each policy scenario, the economy adjusts to a new equilibrium as economic agents respond to these shocks via changes in relative prices. The differences between the initial and post-shock equilibriums are the economic and emissions impacts of the shocks introduced.

3.2. Scenario descriptions

3.2.1. Baseline scenario

Economic projections

The economy, its industries and regions are projected out to 2050 drawing on official Treasury forecasts (Treasury, 2022) and longer term projections (Treasury, 2021) to create an economic baseline against which alternative counterfactuals – ETS policy options in this case – can be compared.

Emissions projections

Economy-wide greenhouse gas emissions are initially generated from the baseline economic activity by industry projections, using emissions intensity coefficients, along with exogenously imposed energy efficiency improvements that largely reflect historical trends.

We then adjust aggregate gross emissions through technological change parameters to align with the Climate Change Commission's (CCC) 'Current Policy Reference' (CPR) track out to 2050 (CCC, 2022). We trend down agricultural emissions in line with the CPR track.

The baseline also draws on the CCC's projected NZU price for the CPR, at $35 real per unit.

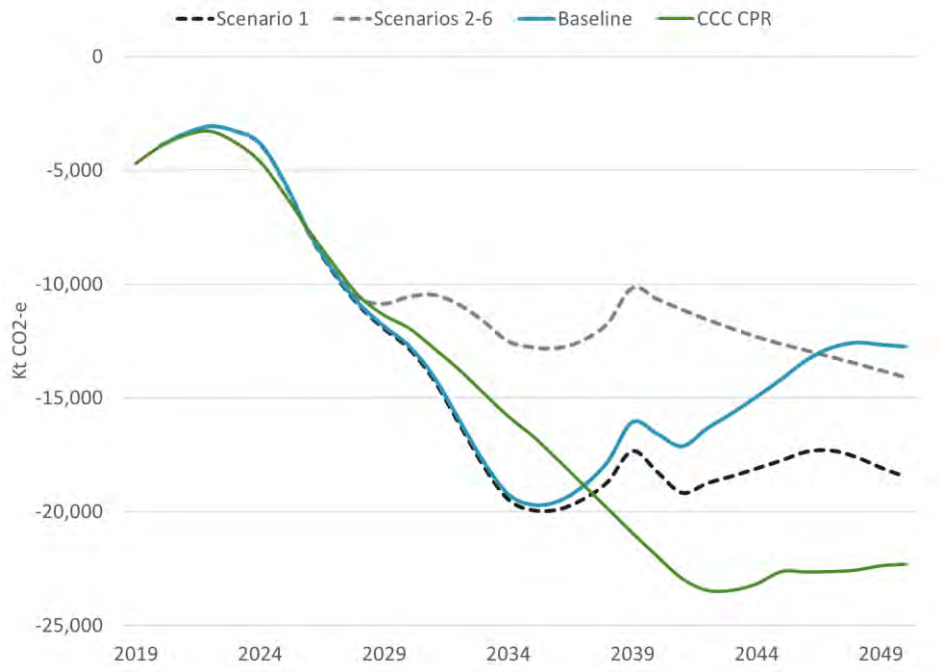
[18] Coal, coke, and tar products; Natural gas; Petrol; Diesel; Other petroleum products; Heavy Fuel Oil; Other Petroleum Products; Bioethanol; Advanced Ethanol; Biodiesel; Advanced Diesel; Advanced Aviation Fuel; Advanced Marine Fuel; Biomass Fuel; Hydrogen; Light Vehicle Fuel blend; Heavy Vehicle Fuel blend; Aviation Fuel blend; Marine Fuel blend; Manufactured gas; Enteric fermentation; Manure management; Ag soils - excreta + other; Ag soils – fertiliser; Urea - CO2; Liming; Field burning; Coal mining fugitive; Gas fugitive; Oil fugitive; Chemical process; Non-metallic mineral processing; Metals processing; Geothermal fugitive; Sewerage treatment fugitive; Waste processing fugitive; Land use, land use change, forestry.

Forestry planting and removals

Projected forestry removals for our baseline and policy scenarios were provided to us by Climate Forestry Association (CFA). As shown in Figure 4, CFA expects considerably fewer removals in the outyears than government projections (the green line) suggest.

The primary source of variance between our baseline and government projections arises from differences in planting expectations for the post 2030 period.

FIGURE 4 FORESTRY REMOVALS IN BASELINE & POLICY SCENARIOS



SOURCE: MODELLERS' ESTIMATES BASED ON CCC, CFA

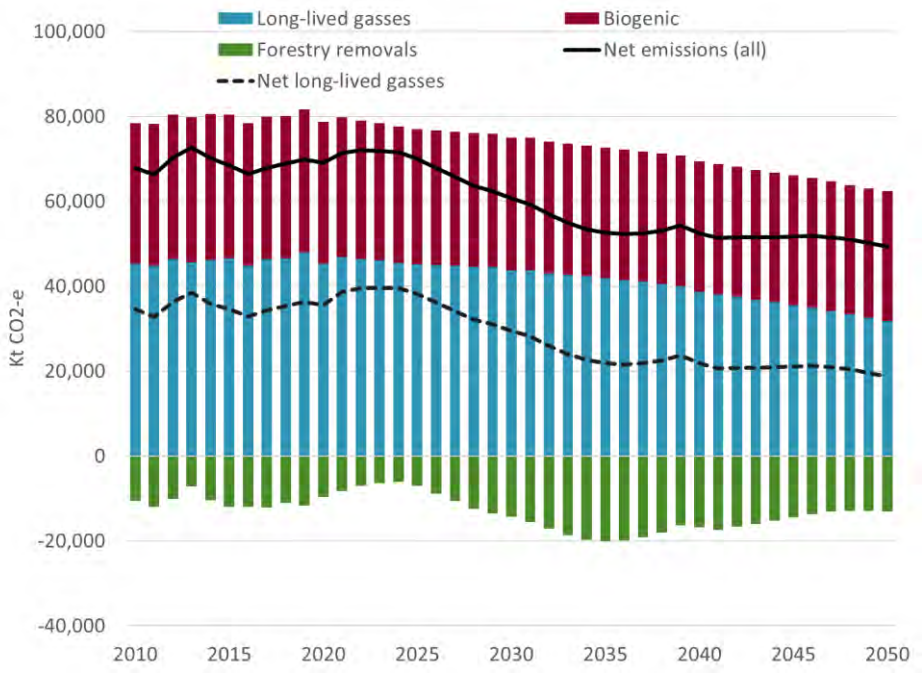
Under these assumptions, baseline net long-lived emissions are around 18.8Mt CO2-e by 2050. Biogenic methane emissions are 30.5Mt CO2-e in 2050 (Figure 5).

Treatment of Nationally Determined Contribution

In both the baseline and policy scenarios we assume the government will purchase offshore emissions permits in 2030, 2040 and 2050 to meet its NDC obligations. We assume a constant world price of $100/t CO2-e in real terms.[19]

[19] This assumption was informed by the range of prices considered by Treasury (2023) in its assessment of the cost of meeting our 2030 NDC target. We used the geometric average of the Treasury's high and low scenarios ($41 to $227) and rounded to the nearest $10. This price is likely conservative compared to the assessment of future prices paths by other commentators.

FIGURE 5 BASELINE EMISSIONS PROJECTIONS



SOURCE: MODELLERS' ESTIMATES BASED ON CCC, CFA

3.2.2. Policy Scenario 1

Our policy scenarios all measure the economic impacts of getting to net zero, with the only differences being:

(i) The way removals are treated in the ETS.

(ii) Expected sequestration pathways.

The first counterfactual or policy scenario retains existing ETS settings for forestry and exogenises emissions to meet our legislated Zero Carbon Act targets by 2050. That is, net zero for long lived gasses by 2050, plus a 24% decrease in methane from 2017 levels.[20]

The forestry removals track for this scenario was sourced from CFA (see black dotted line in Figure 4). It is stronger (i.e. more removals) than our baseline track, consistent with the NZU price being higher than in the baseline as the economy moves to net zero.

[20] We have taken the lower bound of the methane target of 24-47% reduction on 2017 levels in order to be conservative. A larger methane cut would have greater economic cost unless there are breakthroughs in on-farm emissions-reduction technologies such as a methane vaccine.

3.2.3. Policy Scenarios 2-6

Our other policy scenarios explore aspects of the Consultation's Option 3 and Option 4.

Option 3 seeks to "create different prices for units sold at auction and those allocated from removal activities" (Consultation, p.62). One example of such an approach described in the Consultation (p.62) is to "[r]estrict the number of units that can be allocated from removal activities. This could involve certain removal activities (eg, sequestration from exotic pine forests) being allocated a reduced number of units relative to the actual amount of CO2 they have sequestered (eg, 1 NZU for 2 tonnes of CO2)".

Option 4 seeks to create "two markets with two separate prices: one for gross emissions reduction activities and another for removal activities. Emitters would only be permitted to use units sold at auction or allocated for emissions intensive and trade-exposed activities to meet their surrender obligations, while removal activities would be incentivised through a separate market" (Consultation, p.65). That is, emitters would not be able to use forestry removals to meet their obligations.

While Option 3 and 4 might have different institutional mechanisms, they collapse into essentially the same conceptual picture: foresters receive a price that is *lower* than the prevailing NZU price; and emitters pay a price that is *higher* than the NZU price.

In all our other policy scenarios, we assume differential pricing. From 2025[21] foresters receive 50% of the prevailing NZU price – effectively the 2-for-1 discount mooted in the Consultation. The removals track for these scenarios, again sourced from CFA, is softer than the baseline (see grey dotted line in Figure 4) as the policy changes create weaker incentives for afforestation.

This is consistent with the Consultation's expectations for Option 3 ("Without additional measures to encourage more removals, this option is likely to result in less removal activity", p.62).

There is no indication in the Consultation of the extent of any premium relative to the NZU price that emitters might face. To give a sense of how the costs of getting to net zero might change with such a premium, we run a range of scenarios, from 0% to 200% of the prevailing NZU price.

TABLE 3 OVERVIEW OF POLICY SCENARIOS

Scenario name	Discount on forestry NZUs	Premium on emitters' NZUs	Removals projection (see Figure 4)
Scenario 1	None	None	Higher than baseline
Scenario 2	50%	None	Lower than baseline
Scenario 3	50%	50%	
Scenario 4	50%	100%	
Scenario 5	50%	150%	
Scenario 6	50%	200%	

[21] 2025 being the date nominated in the consultation from which these changes will take effect.

It is important to note that **we are not suggesting what any NZU discounts or premia *should* or even *might* be.** There is insufficient information in the Consultation, so we use a range of figures to generate our economic impact estimates. We are happy to analyse alternative combinations of this differential pricing approach should more policy detail become available.

As in Scenario 1, we exogenise emissions to meet our domestic net zero targets by 2050, and assume government buys offshore carbon units to meet its NDC obligations as required.

3.3. Key model closure choices

The closure of a CGE model refers to the elements that we tell the model about (exogenous variables) and those which we want the model to tell us about (endogenous variables). Closure choices are important in any piece of CGE modelling as they represent the way we conceptualise certain parts of the economy adjusting to shocks.

In the policy scenarios conducted for this report, the closure contained several key blocks of settings:

- The real balance of trade (BOT) was fixed as a share of real GDP.
    - This means the BOT can't expand as a share of GDP. Any additional investment is funded more by domestic savings than foreign borrowing.
    - The average propensity to consume of out GNP is endogenised.
- Real wages are sticky in the short run.
    - This means the immediate labour market impacts of policy shocks are seen largely through changes in employment.
    - Over time, employment trends back towards baseline and real wages adjust to clear the labour market.
- The ratio of the central government budget balance to gross domestic is exogenised at the baseline level.
- Population growth, net immigration and land supply growth are exogenous.
- Nominal interest rates on government debt are exogenous.
- The nominal exchange rate is exogenous, but the real exchange rate is determined by the model.
- Most industry-specific and commodity-specific technological change and preference variables are exogenous.
- However, all industries generating combustion emissions are able to respond to rising carbon prices by increasing their rate of investment in emissions-reducing technologies (i.e. endogenous technological change with respect to carbon prices).

Alternative assumptions about the path of the balance of payments in particular can influence welfare results. We have not explored alternative closure options for this project due to time constraints but this is an option for follow-on work.

Another key set of closure choices relates to modelling the ETS and NDC. In all policy scenarios we:

- Exogenise long-lived ETS emissions such that they trend down to net zero by 2050.
- Exogenise agricultural emissions to be 24% below 2017 levels by 2050.
- Exogenise forestry afforestation and removals based on FCA projections[22], and assume marginal forestry substitutes largely for sheep and beef activities on marginal land.
- *Endogenise* the NZU price so that it clears the emissions market(s).
- Exogenise international permit prices at $100 per tonne (real). The government purchases offshore permits in 2030, 2040 and 2050, with the volume of permits determined by the gap between our actual emissions and the NDC in each year.[23]

However, the removals tracks provided by FCA, relative to the baseline, are directionally consistent with NZU prices that are higher (Scenario 1) or lower (Scenarios 2-6) than the baseline.

A full list of our closure choices is available on request.

[22] Ideally, we would want afforestation and removals to be directly related to the NZU price within the model (i.e. planting and sequestration would be endogenously determined, dependent on the NZU price and other commercial drivers). This was not feasible in the very limited time available for this project but remains an important area of model development. The approach we take here is similar to that of the CCC's 2021 analysis and other CGE modelling exercises related to New Zealand's net zero target (e.g. NZIER, 2018).

[23] New Zealand does not yet have a 2040 or 2050 NDC. For the purposes of this project, we align the 2050 NDC with domestic targets and interpolate between 2030 and 2050 to generate a 2040 NDC.

4. Economy-wide modelling results

4.1. Macroeconomic impacts

4.1.1. GDP and welfare impacts

Reducing the role of forestry removals makes it 3-4 times as expensive to meet our net zero targets…

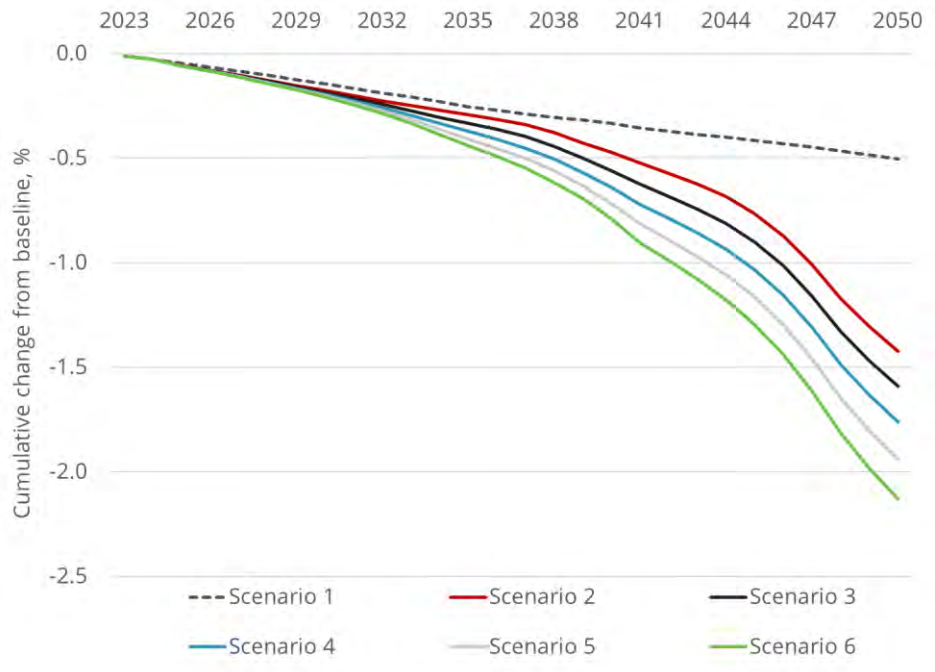
Reducing the role of forestry removals materially increases the cost to the economy of meeting New Zealand's net zero targets (Figure 6).

Under existing ETS forestry settings, we estimate getting to net zero by 2050 would lead to the economy being 0.5% smaller than baseline (the Scenario 1 dashed line).[24]

In our differential pricing scenarios, that GDP cost rises to between 1.4% and 2.1% by 2050.

That is, reducing the role of forestry – under our assumptions – would make it three to four times more expensive for New Zealand to meet its net zero target.

FIGURE 6 CUMULATIVE CHANGE IN REAL GDP FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

…as carbon prices rise more substantially than under current ETS policy settings

The additional GDP impacts stem from emitters facing a higher cost of carbon when forestry is priced to be less attractive or is otherwise disincentivised. More of the hard work in getting to

[24] This is around half the cost that the CCC (2021) estimated, primarily because our model incorporates endogenous technological change to a higher carbon price. We also impose fewer constraints on industry output, which allows a more flexible and efficient adjustment of output across sectors.

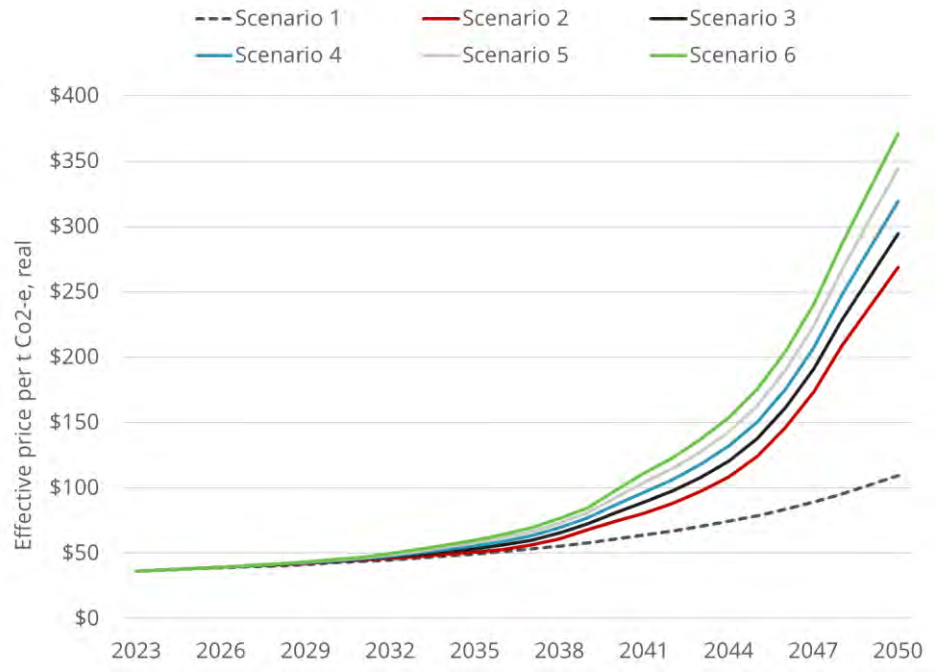
net zero comes through gross emissions reductions, which are more expensive than forestry removals.

This increases emitters' production costs and leads to a contraction in output. While there is some investment in emissions-reducing technologies in response to the higher carbon price, it is not sufficient to offset the decrease in output.

The shape of the economic cost curves is largely determined by the carbon price path. Figure 7 below shows the costs that emitters could face under the various policy scenarios. It differs from the previous chart because emitters will pay more than the 'average' NZU price under differential pricing scenarios as envisaged by the Consultation.

As the share of sequestration falls relative to the decrease in gross emissions required to meet the net zero target, the effective NZU price rises more sharply.

FIGURE 7 LEVEL OF EFFECTIVE NZU PRICE FACED BY EMITTERS, $ PER TONNE CO2-E



SOURCE: MDG-NZ MODELLING

GDP costs rise from $3.4bn to $9.5bn - $14.2bn by 2050

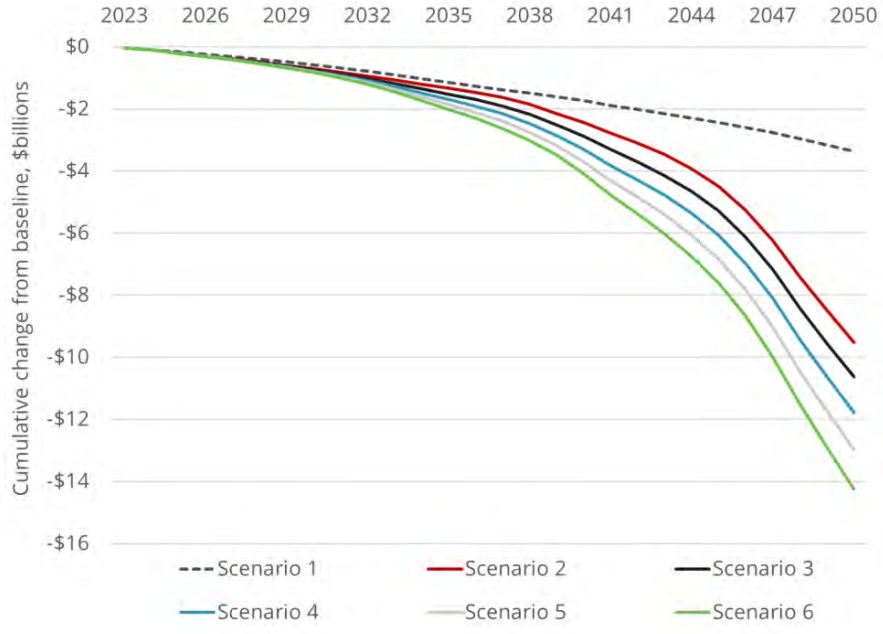
In dollar terms, the GDP cost of getting to net zero increases from $3.4 billion by 2050 under current settings to between $9.5 billion to $14.2 billion by 2050 (Figure 8). The greater the differential between the price foresters receive for their units and the price emitters pay to meet their obligations, the larger the GDP cost of getting to net zero.

We proxy welfare impacts through changes in real Net Domestic Product (NDP). NDP adjusts GDP for the consumption of fixed capital used in the production process.[25] As Figure 9 shows,

[25] NDP accounts for reductions in the value of a country's assets due to wear and tear, aging or obsolescence. It can be seen as "an estimate of sustainable product, which is a rough measure of the level of consumption that can be maintained while leaving capital assets intact" (BEA, n.d.).

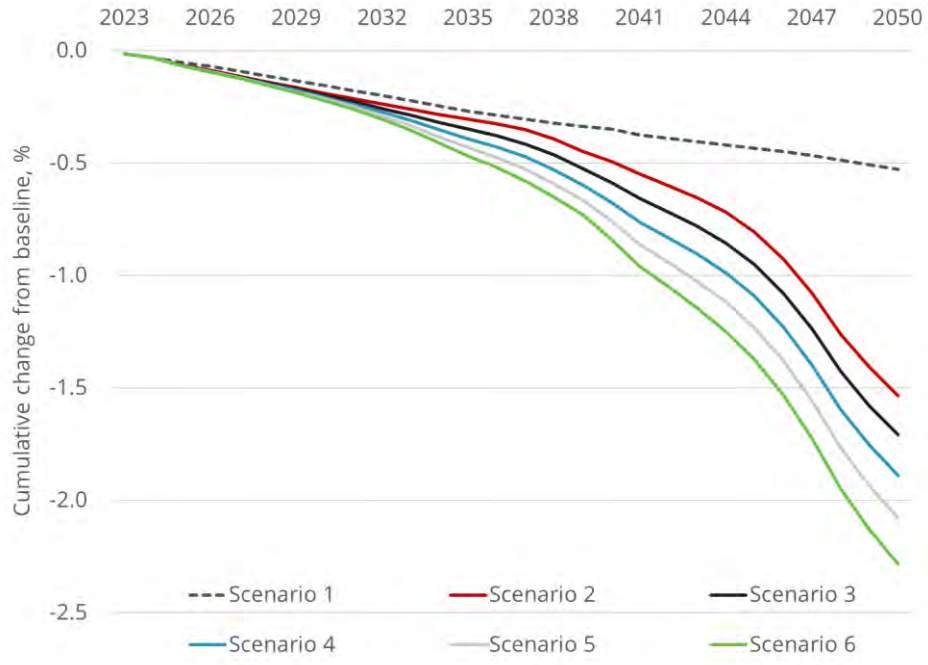
the welfare impacts are slightly larger than the GDP impacts. This is because depreciation is fixed in real terms as the capital stock is fixed in any one period. As real GDP goes down in our policy scenarios, then depreciation is a larger share of NDP.

FIGURE 8 CUMULATIVE CHANGE IN REAL GDP FROM BASELINE, $ BILLIONS



SOURCE: MDG-NZ MODELLING

FIGURE 9 CUMULATIVE CHANGE IN REAL NDP FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

Exporters suffer a loss of international competitiveness as carbon costs rise

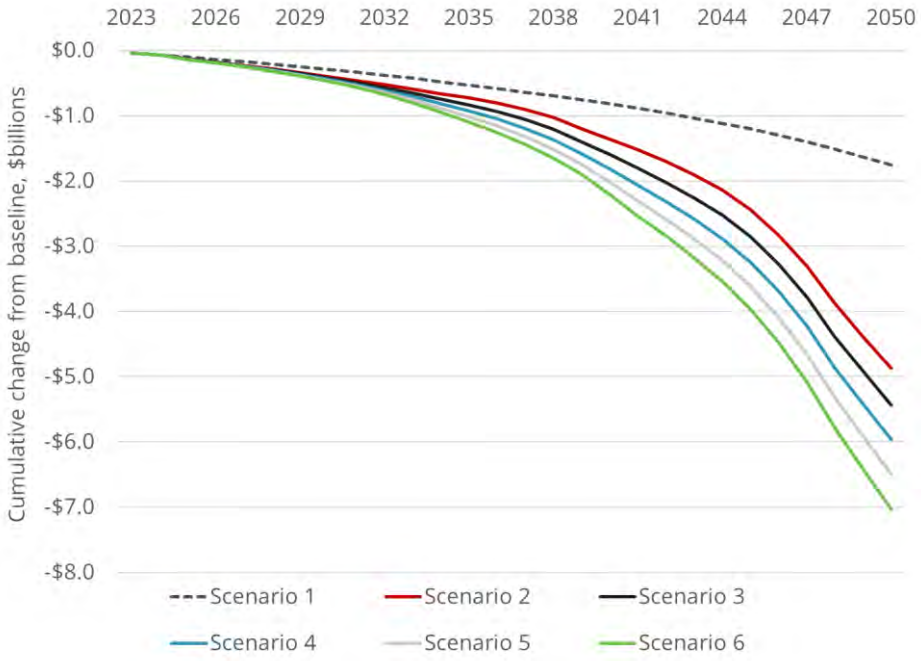
As exporting firms face a higher carbon price, their costs rise relative to their competitors, leading to a loss of international competitiveness. Exports fall as a result (Figure 11).

We estimate the real value of exports drops by between $4.9 billion and $7.0 billion in the differential pricing scenarios, compared to $1.8 billion if we move to net zero under current ETS forestry settings.

The largest drops in primary sector exports stem from dairy products (3.9% below baseline by 2050 in Scenario 4), meat products (6.7%), seafood (5.1%).

In the manufacturing sector, emissions-intensive industries such as chemicals (down 37.4% by 2050), non-metallic minerals (down 52.3%) and primary metal manufacturing (down 43.0%) suffer most. Higher fuel costs also feed into weaker tourism demand, with air transport exports dropping 49.0% below baseline by 2050 in Scenario 4.

FIGURE 10 CUMULATIVE CHANGE IN EXPORTS FROM BASELINE, $ BILLIONS



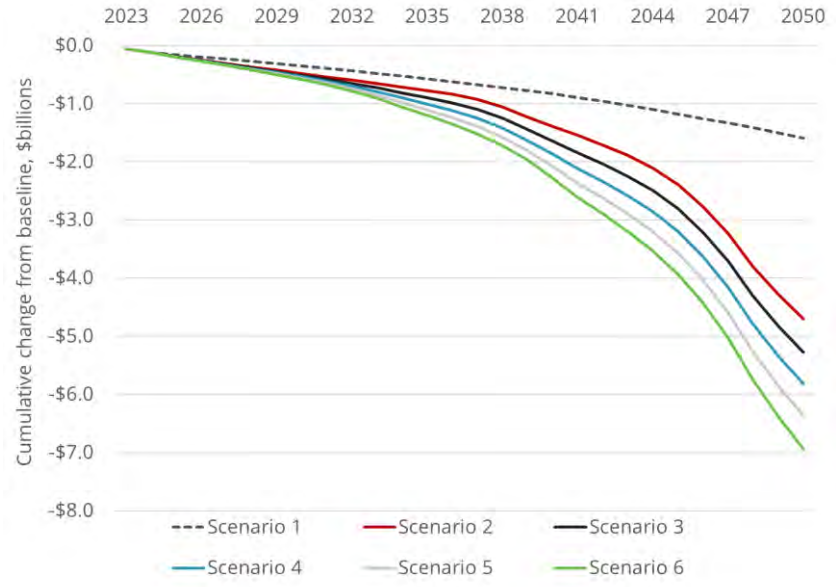
SOURCE: MDG-NZ MODELLING

Investment falls as profit margins are squeezed and production declines

As industry margins are eroded by higher carbon prices, lower exports and weaker household spending, profits decline. This in turn leads to lower aggregate investment across the economy, despite the induced boost to investment in emissions-reducing technologies.

We estimate investment could fall by between $4.7 billion and $6.9 billion below baseline by 2050 in the differential pricing scenarios, some three to four times as much as under current ETS forestry settings ($1.6 billion).

FIGURE 11 CUMULATIVE CHANGE IN INVESTMENT FROM BASELINE, $ BILLIONS



SOURCE: MDG-NZ MODELLING

4.1.2. Labour market and household spending impacts

A slower growing economy reduces the demand for workers

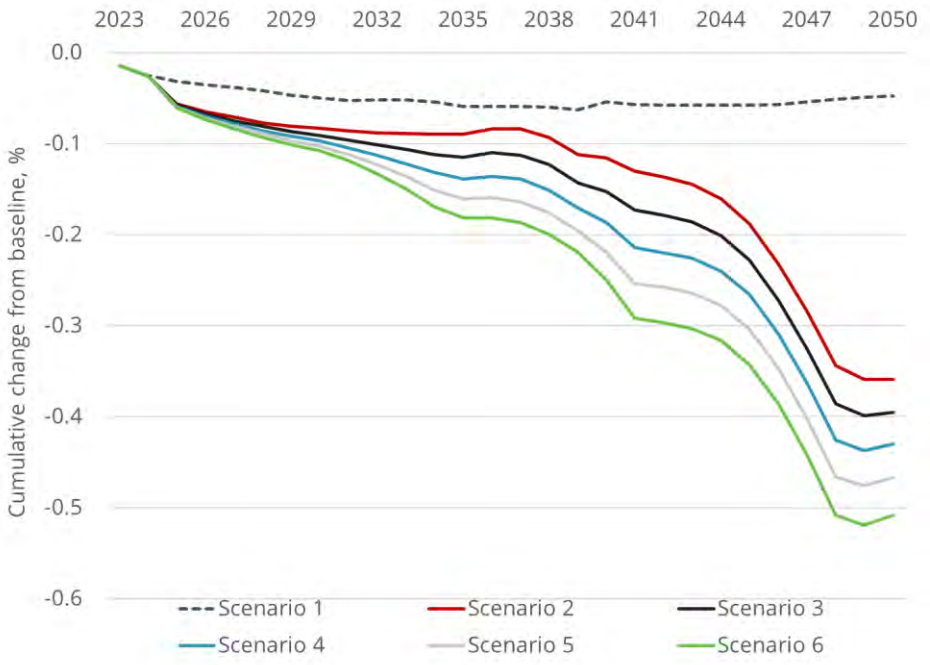
As the level of economic activity decreases below the baseline in the differential pricing scenarios, the demand for labour follows suit: lower output requires fewer workers, holding all else constant.

Figure 12 shows aggregate employment could fall by between 0.36% and 0.51% below baseline by 2050. This compares to just 0.05% in the current ETS setting scenario.

Relative to Scenario 1, these changes equate to:

- between 2,900 to 6,600 fewer FTEs by 2040
- between 5,700 to 10,900 fewer FTEs by 2050.

FIGURE 12 CUMULATIVE CHANGE IN EMPLOYMENT FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

An unjust transition? Lower-skilled workers will be hardest hit

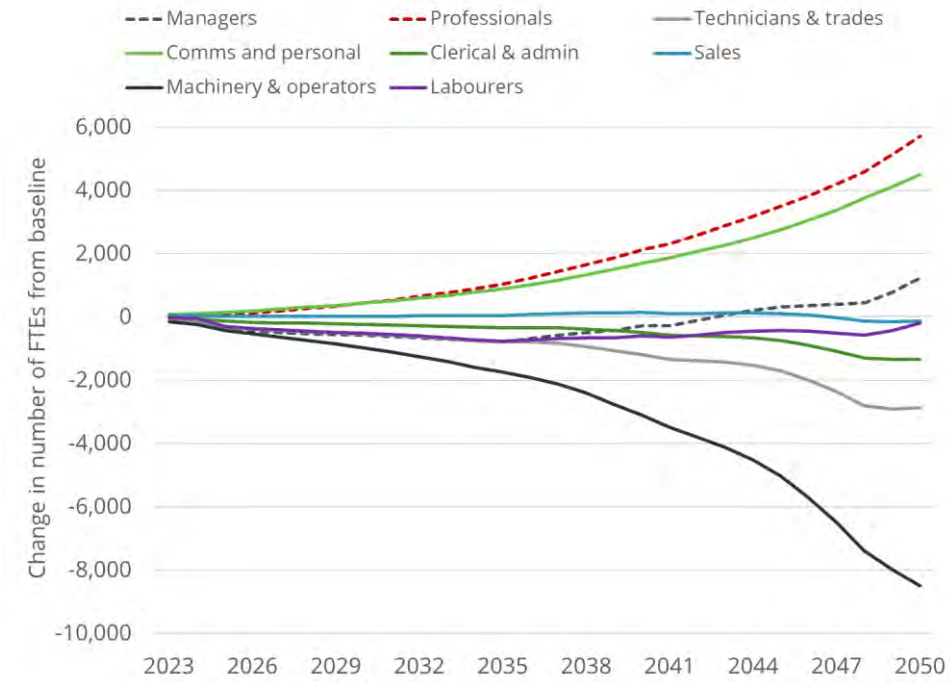
The employment impacts of restricting the role of forestry removals in meeting our net zero targets will be felt more acutely by lower-skilled occupations.

Figure 13 shows the change in Full Time Equivalent (FTE) jobs by occupation, relative to the baseline, for Scenario 4. The dotted lines represent what might be thought of as more highly-skilled roles – managers and professionals. Employment in these roles grows relative to baseline, primarily because the professional services sector where most of them work is less severely affected by the rising carbon price.

The solid lines show the potential employment impacts for lower-skilled roles such as labourers and technicians and tradespeople are worse than those for higher-skilled roles. This reflects the greater share of such workers in sectors that are hardest hit by a higher carbon price, such as farming, mining, primary processing, metal and minerals manufacturing.

This suggests the Consultation's options may pose a threat to the government's desire to ensure a 'Just transition' towards a lower emissions future.

FIGURE 13 CUMULATIVE CHANGE IN FTES BY OCCUPATION FROM BASELINE, SCENARIO 4



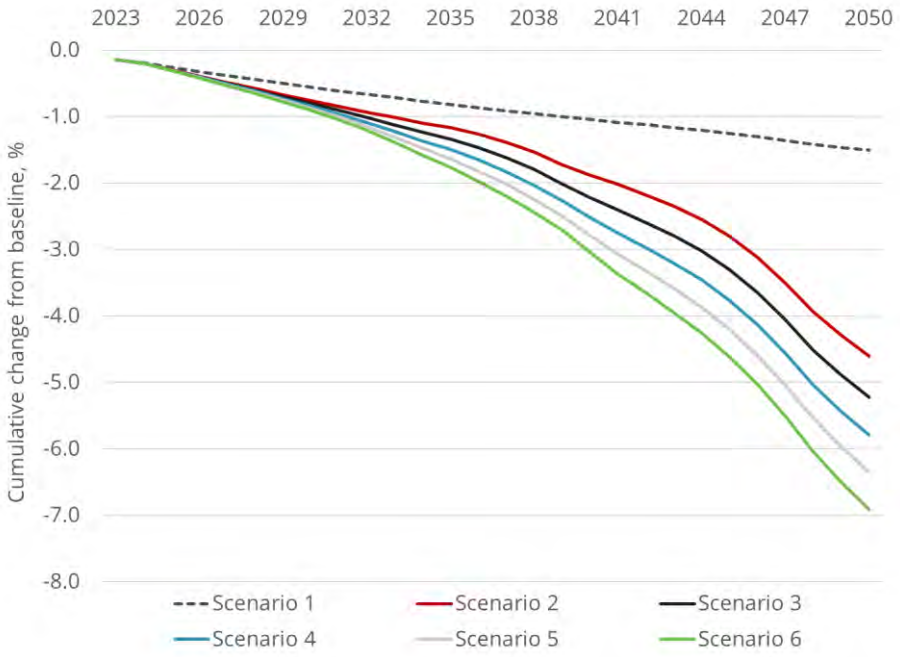
SOURCE: MDG-NZ MODELLING

TABLE 4 IMPACTS ON OCCUPATIONS, CHANGE IN FTE JOBS FROM BASELINE, 2050

	Scenario					
Occupation	**1**	**2**	**3**	**4**	**5**	**6**
Managers	4,573	3,100	2,029	1,225	545	-82
Professionals	1,105	4,100	4,964	5,721	6,419	7,087
Technicians & Trade workers	-428	-2,440	-2,654	-2,879	-3,132	-3,427
Community & Personal Service workers	1,068	3,454	4,003	4,493	4,954	5,405
Clerical & Administration workers	-248	-1,188	-1,259	-1,334	-1,421	-1,525
Sales workers	-217	-305	-194	-127	-91	-80
Machinery operators & drivers	-2,006	-6,914	-7,741	-8,488	-9,213	-9,951
Labourers	3,080	1,394	499	-193	-794	-1,357

Real wages fall as labour demand weakens, especially over the longer term

FIGURE 14 CUMULATIVE CHANGE IN REAL WAGES FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

In the short-term, we assume real wages are 'sticky', meaning they take time to adjust to changes in economic conditions and changes in labour demand are seen primarily through changes in employment. Over the longer term, employment gradually returns to its baseline level and soft labour demand is seen mainly through lower real wages (Figure 14).

We estimate real wages across the economy could be between 4.5% and 7.0% lower than baseline by 2050 if forestry removals play a smaller role in meeting our net zero targets.

Fewer jobs, lower wages and a weaker NZD makes households worse off

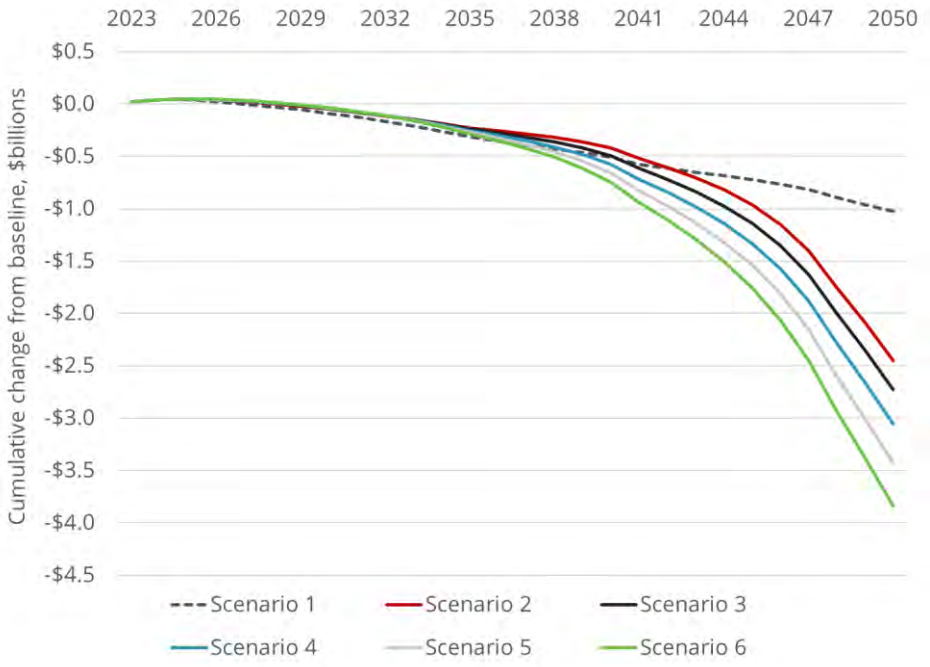
Household spending is significantly lower than the baseline in the differential pricing scenarios. This is driven by a combination of lower employment, lower real wages and a weaker NZD (required to compensate exporters for their reduced competitiveness) that makes imported goods and services more expensive.

The result is that households spend between $2.5 billion and $3.8 billion less than baseline by 2050, compared to a drop of $1.0 billion if existing ETS forestry settings are maintained (Figure 15).

That is, households are 2.5 to 3.8 times worse off under the differential pricing scenarios than under current ETS settings on the path to net zero.

B

FIGURE 15 CUMULATIVE CHANGE IN HOUSEHOLD SPENDING FROM BASELINE, $BN



SOURCE: MDG-NZ MODELLING

On a per household basis, average spending will be around $1,100 to $1,600 lower than the baseline by 2050.[26]

4.1.3. Price impacts

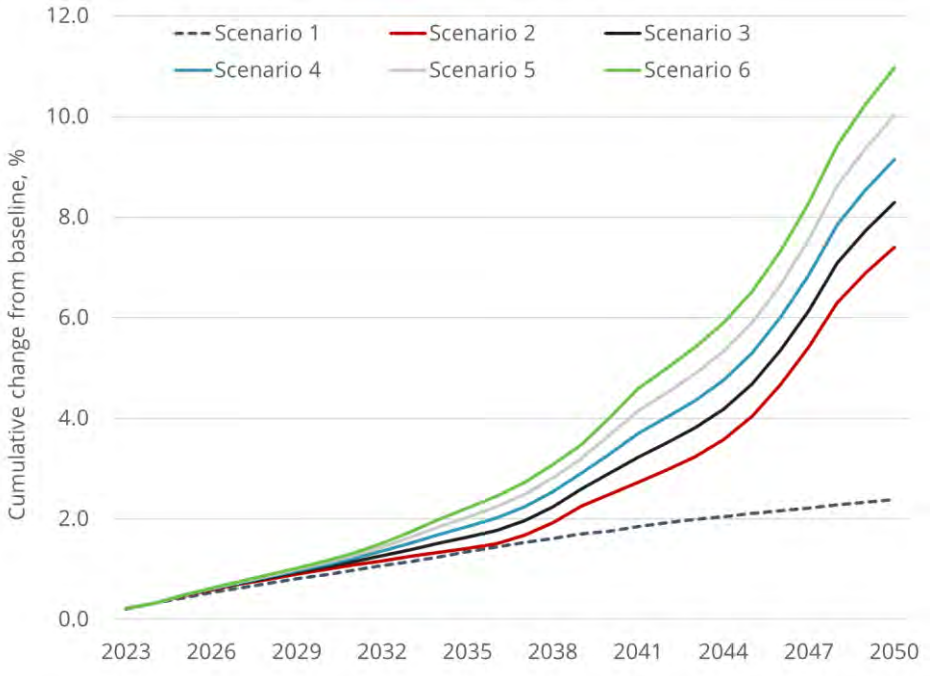
Reducing the role of forestry removals in meeting our net zero targets pushes up the carbon price (Figure 7 above). This then flows through into higher prices for some of the goods and services that households buy.

For example, we estimate light vehicle[27] fuel prices could rise by between 7.4% and 11.0% above baseline by 2050, compared to 2.4% in the current ETS settings scenario (Figure 16)[28] Electricity prices could rise by between 7.4% and 9.1% above baseline by 2050 (Figure 17).

The prices faced by households for other goods and services tend to fall slightly below baseline. This is primarily due to slower economic growth that reduces inflationary pressures. Real wage declines (see Figure 14) benefit industries with high labour shares, such as retail and professional services, allowing them to cut their prices.

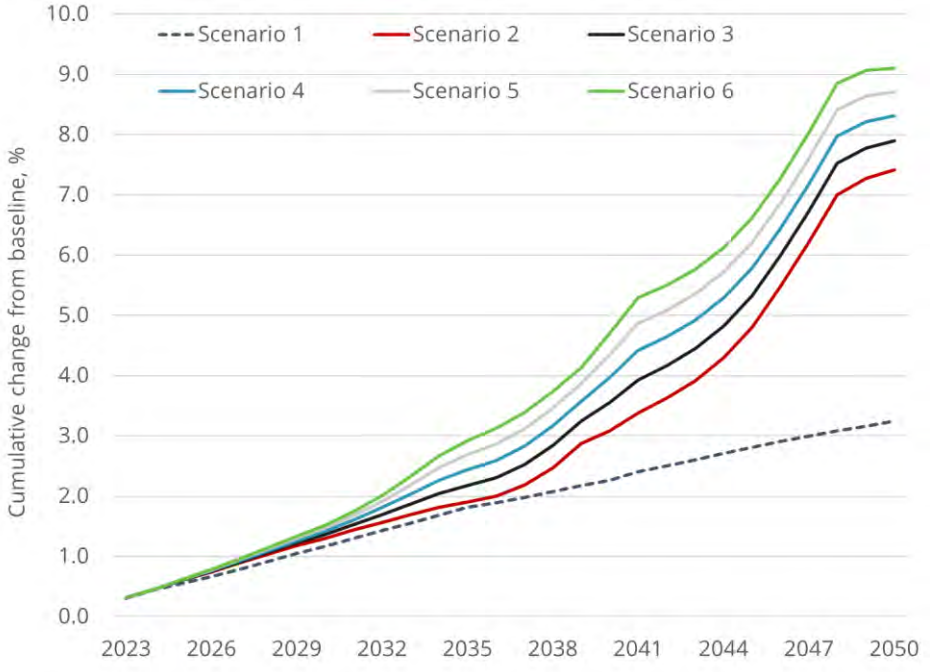
[26] Drawing on StatsNZ's 2018 base household projections to 2043 extrapolated out to 2050.
[27] Light vehicles include passenger and commercial vehicles such as cars, vans, utes, SUVs and 4WDs.
[28] We acknowledge many households will, over time, switch to electric vehicles and thus may not face this increase in light vehicle fuel prices.

FIGURE 16 CUMULATIVE CHANGE IN LIGHT VEHICLE FUEL PRICE FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

FIGURE 17 CUMULATIVE CHANGE IN ELECTRICITY PRICE FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

4.1.4. Fiscal impacts

Government tax revenue drops sharply as the economy grows slower…

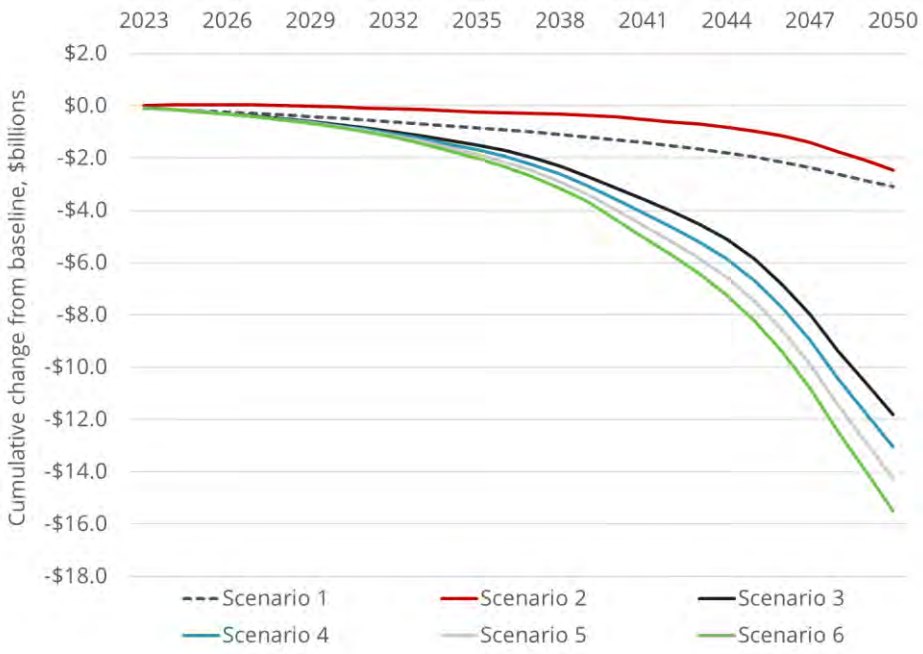
Under all the scenarios where forestry plays a smaller role in meeting our emissions targets, government's tax take declines markedly (Figure 18).

This is driven mainly by a decline in personal income taxes (which accounts for around 80% of the drop) as employment softens and real wages fall.

The decline in overall tax revenue occurs despite the government receiving a 'margin' on its NZU sales to emitters relative to the price it pays to foresters.

Indeed, the larger the differential between the price received by foresters for NZUs and the price paid by emitters at auction, the larger the drop in overall tax receipts. This is because the higher the margin, the higher the carbon price rises and the larger the contraction in economic activity (and hence income and corporate taxes) from the baseline.

FIGURE 18 CUMULATIVE CHANGE IN TAX REVENUE FROM BASELINE, %



SOURCE: MDG-NZ MODELLING

…contributing to a worsening fiscal balance and increase in government debt

The decline in tax revenue sees the fiscal deficit worsen by between $3.7 billion and $5.4 billion below baseline in 2050 (Figure 20). Additional government borrowing is required to fund spending commitments, including offshore unit purchases (Figure 21).

This increases the tax burden on future generations of meeting our net zero targets as the additional debt needs to be serviced.

Additional offshore units will need to be purchased to meet our NDCs

Government purchases of offshore emissions credits to meet our assumed NDC targets[29] are included in government spending in 2030, 2040 and 2050.

As Table 5 shows, government purchases of offshore units are higher in the scenarios where the role of forestry is reduced (Scenarios 2-6) than when our net zero targets are reached under existing ETS settings (Scenario 1).

At $100 (real) per unit, the additional government purchases amount to $140 million in 2030, $510 million in 2040 and $40 million in 2050 – some $690 million in total.

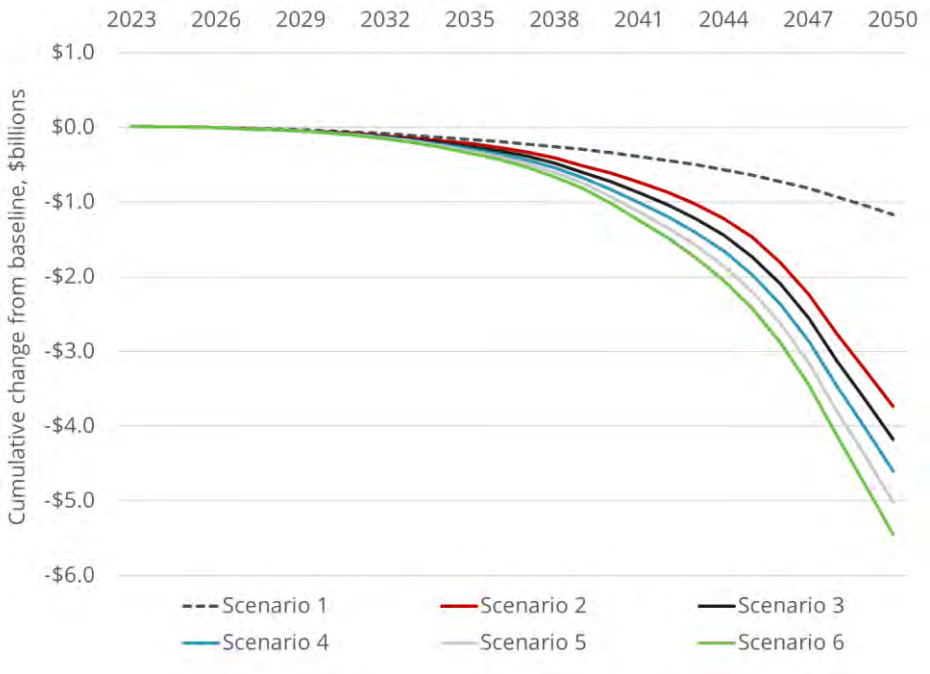
TABLE 5 OFFSHORE PURCHASES REQUIRED TO MEET ASSUMED NDCS

Net emissions, , Kt CO2-e			
	Scenario 1	**Scenarios 2-6**	**NDC target**
2030	54,016	55,372	41,330
2040	37,905	43,046	20,665
2050	25,513	25,905	0
Offshore purchases required, Kt CO2-e			
	Scenario 1	**Scenarios 2-6**	**Diff (2-6) less 1**
2030	12,685	14,042	1,356
2040	17,240	22,381	5,142
2050	25,513	25,905	392
Cost of offshore purchases, $billions			
	Scenario 1	**Scenarios 2-6**	**Diff (2-6) less 1**
2030	$1.27	$1.40	$0.14
2040	$1.72	$2.24	$0.51
2050	$2.55	$2.59	$0.04

SOURCE: SENSE PARTNERS CALCULATIONS

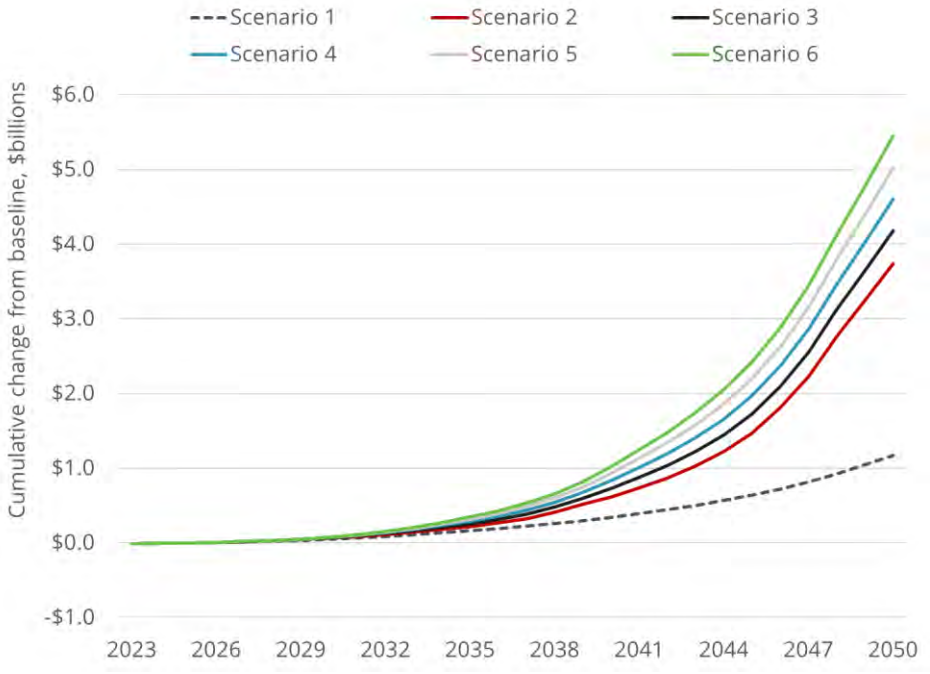
[29] As noted in section 3.3, we align New Zealand's 2050 NDC with our domestic net zero targets and interpolate between 2030 and 2050 to give a 2040 NDC.

FIGURE 19 CUMULATIVE CHANGE IN GOVERNMENT BALANCE FROM BASELINE, $BN



SOURCE: MDG-NZ MODELLING

FIGURE 20 CUMULATIVE CHANGE IN GOVERNMENT BORROWING FROM BASELINE, $BN



SOURCE: MDG-NZ MODELLING

4.2. Industry impacts

Figure 21 overleaf shows the impact on value added (effectively GDP) relative to the baseline by sector for the scenario where government sells NZU at a 100% premium to emitters and pays foresters 50% of the NZU price (Scenario 4). For the sake of simplicity, we show the results for the 79 sectors in 2040 and 2050 only.[30]

The impacts of the policy scenarios on sectors are determined by a range of often-competing factors, including:

- Their direct exposure to rising carbon prices – higher carbon prices increase production costs, forcing output to contract relative to the baseline.
- Their indirect exposure to carbon prices – industries that rely on freight to move their goods around the country and offshore will face higher transport costs, which reduces their profitability and hence output.
- Upstream and downstream supply chain links – if a sector is highly reliant on another sector (e.g. dairy processing and dairy farming), then its fortunes will be driven partly by how the upstream sector fares.
- The extent to which they export or import – the real exchange rate depreciates in all scenarios, which provides a boost to export competitiveness but pushes up the cost of imported inputs.
- Their labour-capital ratios – real wages decline in all scenarios as the labour market softens, which benefits labour-intensive industries.

Key industry impact themes across the differential pricing scenarios are:

- **Primary production** sectors (e.g. dairy farming, sheep and beef farming) contract slightly relative to baseline, as higher carbon prices increase their operating costs through higher input prices (fuel, fertiliser, etc.). In addition, sheep and beef experiences a slight decrease in land use as forestry expands.
- **Downstream processors** such as dairy manufacturing and meat manufacturing contract by similar amounts as their input sectors. A reduction in inputs to be processed more than offsets any gain in competitiveness from a depreciating exchange rate.

  An exception is **beverage and tobacco manufacturing** (essentially New Zealand's wine and craft beer sector), which expands marginally relative to baseline due to it being low emissions and hence less exposed to the carbon price. As a labour-intensive industry it also benefits slightly from labour costs falling and receives a boost from the exchange rage depreciation.
- **Forestry and logging** value added declines from 2025 to 2039 as foresters receive a 50% cut on the prevailing NZU price. Payments for sequestration act as

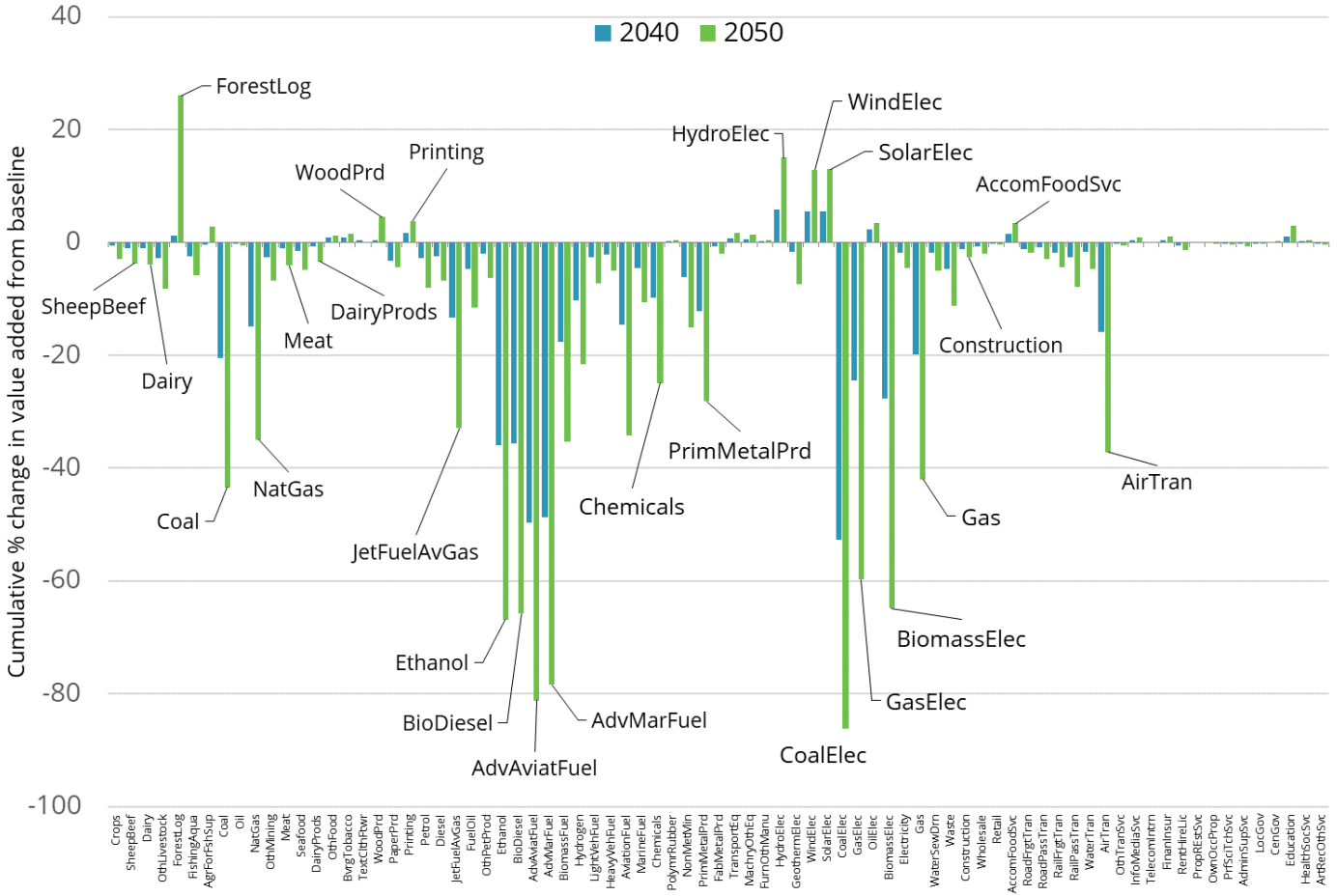
[30] The other scenarios show a similar pattern across sectors, albeit with slightly different levels. A full set of results is available on request.

supplementary revenue to the forestry sector, reducing its net costs without affecting output. The drop in the removals price in the early parts of the projection period therefore pushes up the costs of production relative to other sectors, causing forestry output to contract slightly.

In the outer years, the underlying NZU price starts to rise rapidly as gross emissions are forced down to meet the net zero target. Once the underlying price has more than doubled, even a 50% reduction on that price represents an increase relative to the baseline. This acts to reduce foresters' costs of production relative to the baseline, which leads to an expansion in output.

- Sectors that use forestry's output, such as **wood product manufacturing** and **printing** also expand slightly in the out years as more wood becomes available and the exchange rate depreciates.
- Sectors producing **biofuels** or **blended fuels** see large *percentage* declines in output as the economy shrinks relative to the baseline, but these are from a very low base as New Zealand produces almost nothing of them – so the *dollar value* of these declines is very small.
- **Extractive sectors** such as coal mining, oil and gas extraction and **fossil fuel electricity generation** sectors experience falls in output as the move to net zero incentivises more **renewable energy generation** (see hydroelectricity, wind electricity, solar electricity). These sectors are also relatively capital intensive, much of which is imported and hence becomes more costly.
- Emissions-intensive **heavy manufacturing** sectors, such as chemicals, primary metal production and non-metallic mineral product manufacturing contract as the carbon price rises, pushing up their production costs. This more than offsets any export gains from the depreciating exchange rate.
- Road, rail and especially air **transport** sectors suffer as their fuel costs rise and demand drops as the economy contracts relative to the baseline.
- Most **services** sectors experience little change, with the dampening effect on demand from weaker household spending being offset by a reduction in labour costs as real wages decline.
- **Education** benefits from an increase in the number of people unemployed, as some return to the education sector, and also through increased education exports (i.e. foreign students) as the exchange rate depreciates.

FIGURE 21 CUMULATIVE CHANGE IN INDUSTRY VALUE ADDED FROM BASELINE, %, 2040, 2050, SCENARIO 4



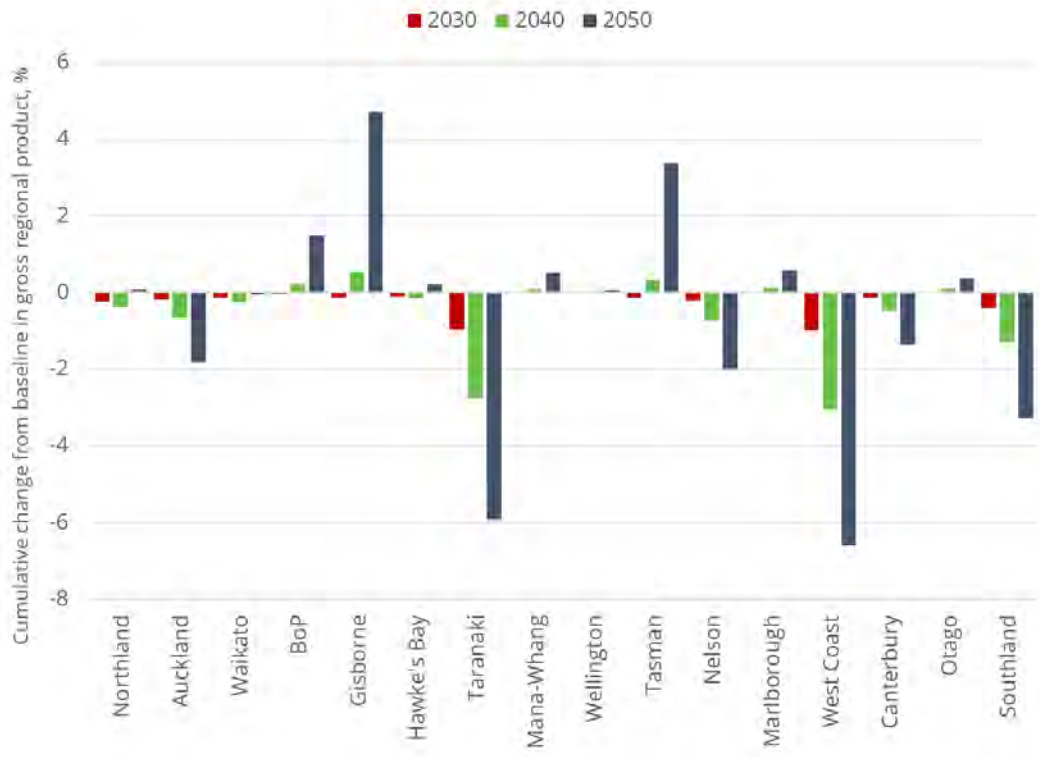
SOURCE: MDG-NZ MODELLING

4.3. Regional impacts

We present here some high-level results, focusing on Gross Regional Product (GRP). To keep things manageable we restrict our analysis to Scenario 4 and 2030, 2040 and 2050 only.

Note that all results are cumulative percentage changes *from the baseline* in 2040 or 2050, rather than changes from 2023. So, for example, Auckland's 1.8% decline in 2050 means its economy will be 1.8% smaller than it would otherwise have been in 2050.

FIGURE 22 CUMULATIVE CHANGE FROM BASELINE IN GROSS REGIONAL PRODUCT, %, SCENARIO 4



SOURCE: MDG-NZ MODELLING

A full set of regional results for each policy scenario is available upon request.

In general, as the differential between the price paid for forestry removals and the price government auctions units to emitters increases, regional impacts worsen. At a very high carbon price (e.g. in Scenario 6), some regional economies (Northland, Hawke's Bay and Waikato) see their small GRP gains switch signs to record small losses by 2050.

Interpreting regional results

Regional GDP impacts in a top-down CGE model are determined primarily by the importance for the regional economy (or not) of the most affected sectors at the national level.[31] For instance:

- Dairy farming has a higher than average share of the Waikato economy, so any decrease in national dairy farming GDP will be more keenly felt in that region.
- Similarly, national level impacts of the policy scenarios on the seafood processing sector will have a proportionally larger effect on the Tasman economy, where fishing, aquaculture and associated processing is a major employer.

Understanding regional impacts therefore requires an understanding of:

(i) Which industries contribute the most to each regional economy; and

(ii) How those industries fare at the national level in the policy scenarios.

A heat map showing each sector's contribution to the regional impacts for 2040 and 2050 is shown in Appendix C for Scenario 4. Here we summarise the key drivers in terms of sectors that made the largest contributions (positive or negative) to the overall regional impact.

Summary explanation of regional impacts

See section 4.2 for an explanation of why sectors expanded or contracted at the national level.

TABLE 6 OVERVIEW OF REGIONAL IMPACTS FOR SCENARIO 4

Region	Change in GRP 2050	Main contributors (expanding sectors)	Main contributors (contracting sectors)
Northland	0.1	• Forestry & logging • Accommodation & food services • Property & real estate services	• Fuel • Other mining • Chemicals • Construction • Dairy farming
Auckland	-1.8	• Education • Finance & insurance • Hydroelectricity • Accommodation & food services	• Air transport • Chemicals • Construction • Primary metal manufacturing
Waikato	-0.1	• Forestry & logging • Hydroelectricity • Education • Accommodation & food services	• Chemicals • Dairy farming • Coal mining • Other mining
BoP	1.5	• Hydroelectricity • Forestry & logging • Property & real estate services • Accommodation & food services	• Chemicals • Gas electricity • Dairy farming • Coal electricity

[31] This is not true of all sectors. Some services sectors (such as personal services e.g. haircuts) tend to be locally produced and locally consumed, rather than being traded across regions. In our modelling framework, the main driver of economic impacts for locally-produced services is regional household incomes rather than national impacts.

Region	Change in GRP 2050	Main contributors (expanding sectors)	Main contributors (contracting sectors)
Gisborne	4.7	• Forestry & logging • Property & real estate services • Professional, scientific & technical services • Retail	• Sheep and beef farming • Crops • Chemicals • Other mining
Hawke's Bay	0.2	• Forestry & logging • Property & real estate services • Education	• Chemicals • Air transport • Sheep & beef farming • Crops • Construction
Taranaki	-5.9	• Forestry & logging • Wood processing • Accommodation & food services	• Natural gas exploration • Construction • Chemicals • Dairy farming • Professional, scientific & technical services
Mana-Whang	0.5	• Forestry & logging • Hydroelectricity • Education • Property & real estate services	• Chemicals • Dairy farming • Sheep & beef farming • Construction
Wellington	0.1	• Air transport • Construction • Chemicals	• Finance & insurance • Education • Accommodation & food services • Professional, scientific & technical services
Tasman	3.4	• Forestry & logging • Property & real estate services • Wood processing • Accommodation & food services	• Seafood processing • Crops • Chemicals • Dairy farming
Nelson	-2.0	• Forestry & logging • Accommodation & food services • Retail • Education	• Air transport • Fishing & aquaculture • Seafood processing • Construction • Chemicals
Marlborough	0.6	• Forestry & logging • Beverage & tobacco manufacturing • Property & real estate services • Accommodation & food services	• Seafood processing • Chemicals • Construction • Fishing & aquaculture
West Coast	-6.6	• Forestry & logging • Accommodation & food services • Wood processing	• Coal mining • Construction • Dairy farming • Other mining • Rental, hiring & licensing
Canterbury	-1.4	• Forestry & logging • Hydroelectricity • Education • Accommodation & food services	• Air transport • Construction • Chemicals • Dairy farming
Otago	0.4	• Hydroelectricity • Forestry & logging • Accommodation & food services • Education	• Air transport • Gas electricity • Other mining • Construction
Southland	-3.3	• Forestry & logging • Accommodation & food services • Education	• Primary metal products manufacturing • Dairy farming • Sheep & beef farming • Coal mining

SOURCE: MDG-NZ MODELLING

4.4. Impacts on Māori

Our CGE database does not yet have economic activity split by ethnicity. However, we can look at potential impacts of the policy scenarios on Māori employment and GDP using an out-of-model assessment.

We have estimated 2023 Māori employment and GDP for the 79 sectors and 16 regions in the MDG-NZ database, drawing on Census, Business Demographics and Household Labour Force Survey data from StatsNZ. This shows, for example, Māori account for 57% of forestry and logging employment in Northland and 75% of meat processing employment in Gisborne.

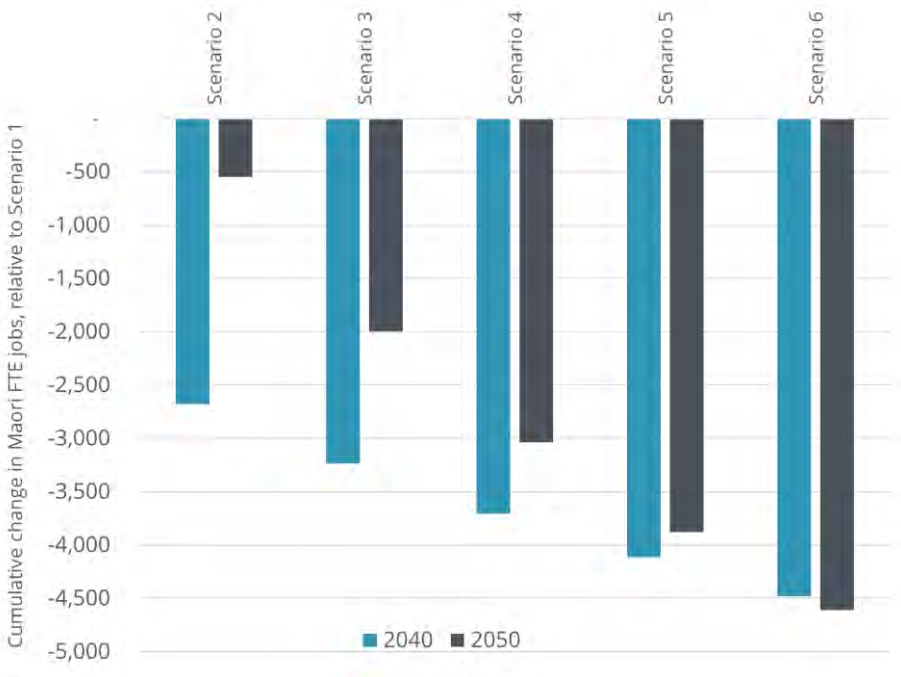
We can use these shares to get a sense of how the modelled industry by region impacts might affect Māori jobs and GDP.

4.4.1. Impacts on Māori employment

We estimate the differential pricing scenarios could lead to a loss of between 2,700 and 4,500 Māori Full Time Equivalent (FTE) jobs in 2040, compared to the scenario where net zero is reached under current ETS settings.

By 2050, Māori job losses could be between 550 and 4,600 greater than in the Scenario 1 scenario, as the sharper contraction of the economy and rapid growth of the forestry sector partly offset each other.

FIGURE 23 CUMULATIVE CHANGE FROM SCENARIO 1, IN MĀORI FULL TIME EQUIVALENTS JOBS, 2040 AND 2050



SOURCE: MDG-NZ MODELLING

Looking just at Scenario 4, relative to the scenario in which New Zealand gets to net zero under current ETS settings (Scenario 1), Table 7 shows the sectors in which Māori job losses are the largest.

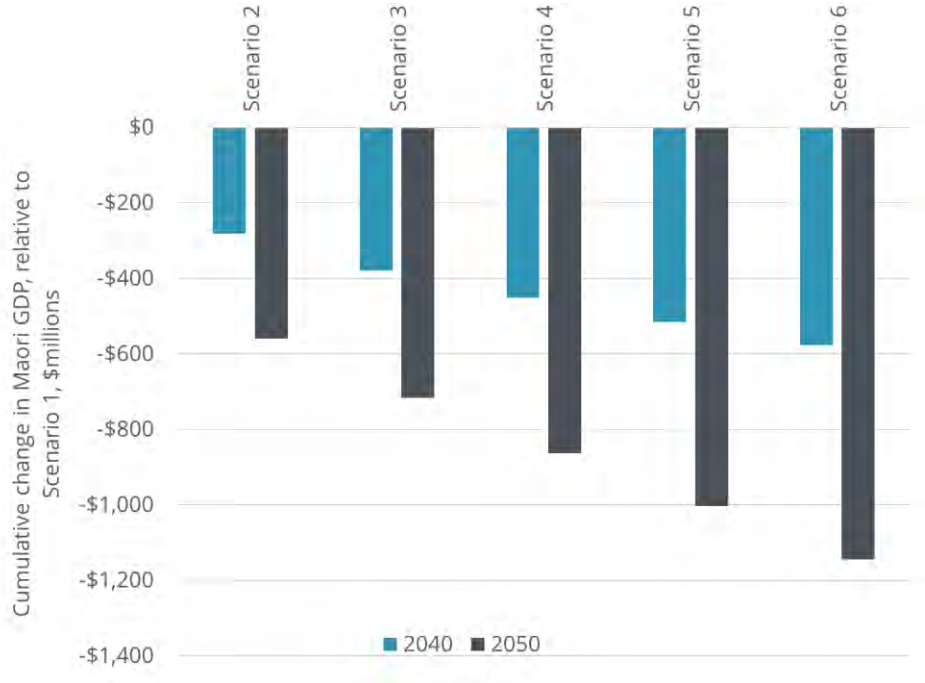
TABLE 7 SECTORS EXPERIENCING THE LARGEST MĀORI JOB LOSSES RELATIVE TO MEETING NET ZERO UNDER CURRENT ETS SETTINGS, SCENARIO 4 ONLY

Sector	Māori FTE employment, relative to Scenario 1, 2040	Māori FTE employment, relative to Scenario 1, 2050
Forestry & logging	-3,170	-2,300
Ag, forestry & fishing services	-1,230	-980
Construction	-500	-1,130
Wood processing	-310	-180
Air transport	-230	-790
Chemicals	-190	-740
Natural gas extraction	-180	-450

SOURCE: MDG-NEW ZEALAND MODELLING

4.4.2. Impacts on Māori GDP

FIGURE 24 CUMULATIVE CHANGE FROM SCENARIO 1, IN MĀORI GDP, 2040 AND 2050



SOURCE: MDG-NZ MODELLING

We estimate Māori GDP could be between $280 million to $580 million lower in 2040, relative to Scenario 1. In 2050, these losses grow to $560 million to $1.14 billion.

4.5. Distributional impacts on households

The overall impacts of the **proposed changes are expected to be regressive**, with price increases affecting lower income households more than higher income households.

Impacts on household expenditure by income quintile are shown in Figure 25. The reductions in expenditure are net of price changes and provide an indication of the relative size of household welfare effects.

Lower income households are worse off because a larger share of their income is spent on products where prices increase and their ability to shift their spending is limited because those products are typically not discretionary e.g.

- property rates or charges for utilities, like water and waste services
- household energy bills
- vehicle fuel costs.[32]

Superannuitants are amongst the worst affected, with real expenditure estimated to decline by 2.2% on average. Again these households tend to have higher than average shares of spending devoted to basics and to maintaining the operation of a household and staying warm.

This assessment is based on existing expenditure shares of households. It is possible that superannuitants' expenditure patterns might change in future.

But the income effects we estimate are highly likely to be relevant in future as it is generally the case that lower income households have less flexibility in how they spend their money and spend a larger share of their money on basics.

Māori households' expenditure is expected to decline by 1.3% on average, lower than the average for all households with a decline of 1.5%. This is largely because Māori households are, based on current data, younger than the average household with lower expenditure shares for utilities and higher expenditure shares on rents (which are expected to decline in relative price as national income is lower).

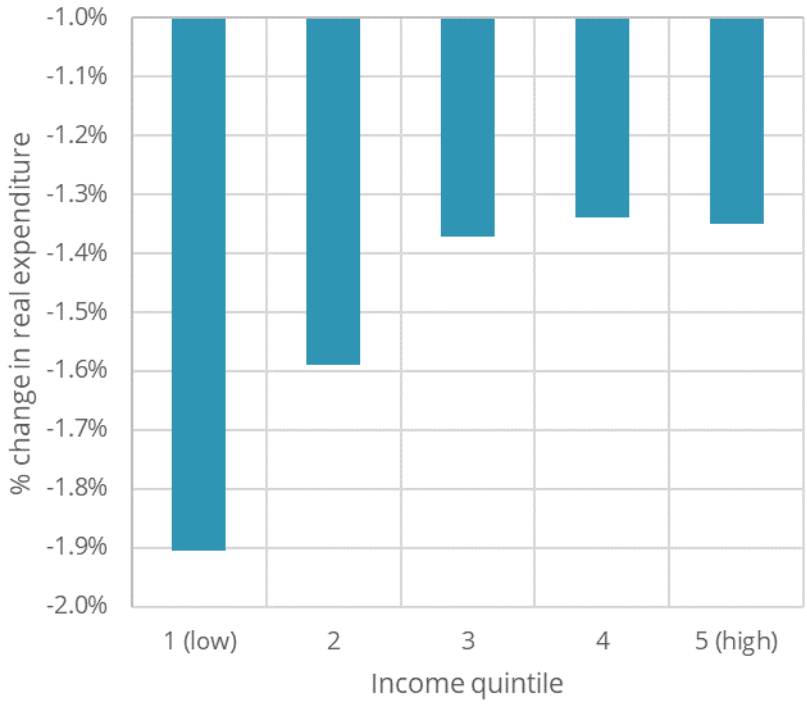
Of course, in future Māori households' average age and expenditure patterns might well change if Māori fertility rates change. In that respect the implications for Māori households are less certain than for low income households.

In any case, expenditure patterns for Māori households will be highly variable. For example, increased transport costs could potentially have a significant impact on the cost of living in more isolated regions of the country like those in the East Coast of the North Island. We expect the cost of running a car to increase by 7%.

[32] Energy costs including electricity and a small amount of petrol.

FIGURE 25: LOW INCOME HOUSEHOLDS WORST OFF

Effect of policy under Scenario 4



5. Conclusions

Officials are proposing major changes to the ETS with minimal analysis to consider their economic impacts

The options put forward by officials in their Consultation document represent a major structural change in the way that New Zealand might meet its international and domestic climate targets.

That they have been put forward with almost no supporting economic analysis to understand their potential impacts on GDP, welfare, the government's fiscal position, jobs, wages, regional development and Māori is highly concerning.

De-emphasising forestry removals comes at a significant cost to the economy

Our modelling demonstrates that materially reducing the role of domestic forestry removals could have significant negative economic implications. Relative to meeting our net zero emissions targets under existing ETS settings, our scenarios indicate that by 2050:

- Real GDP could be between $6.1bn and $10.9bn lower
- Real household spending could be between $1.4bn and $2.8bn lower
- Real exports could be between $3.1bn and $5.3bn lower
- The fiscal deficit could be between $2.6bn and $4.3bn worse, partly due to an additional $690 million of government purchases of offshore units required to meet our NDC targets
- There could be between 5,700 to 10,900 fewer Full Time Equivalent jobs, with lower skilled jobs harder hit than highly skilled roles
- The effective carbon price faced by emitters would be 2.5 to 3.4 times higher.

Poorer households, regional economies and Māori will suffer: the transition to a lower emissions future will become less 'just'

Our modelling also shows regional economies such as the West Coast, Taranaki, Southland and Nelson would suffer the most from ETS changes that reduce the role of forestry in meeting our emissions targets. This is primarily due to having an industry composition that exposes them to the effects of a higher carbon price.

The Consultation's options are regressive in terms of their impacts on household spending. Lower income households, including superannuitants, are relatively worse off than wealthier households, as more of their income goes towards things like transport and electricity, which becomes more expensive as the carbon price rises.

Under our scenarios, there could be between 2,700 and 4,500 fewer Māori Full Time Equivalent (FTE) jobs in 2040, compared to the scenario where net zero is reached under current ETS settings; and between 550 and 4,600 by 2050.

The proposed changes, as we have modelled them, would lead to increased government borrowing of between $3.2bn and $4.7bn compared to meeting our net zero targets under existing ETS settings. This additional debt will need to be paid off over time, increasing the tax burden on future generations.

Core claims about forestry "oversupply" are flawed

These are substantial costs and concerning when you consider that the case for change is not based on evidence.

The core claim underpinning the consultation is that "current market settings are likely to lead to NZU supply exceeding demand from emitters". But the evidence put forward for this is two scenarios from modelling that has the hallmarks of being hurried.

One of the modelled scenarios is acknowledged to be implausible. The other scenario uses a model of forest investment in which "*the impact of the current much higher price (and growers' perceptions of the sustainability of that price) remains to be seen, hence the model's predictive ability is uncertain"*, according to the model's creator.

Both scenarios model forest investment via extrapolation from recent and unrepresentative events.

No consideration of climate risk

Curiously, there is no discussion of the environmental risks of higher global CO_2 concentrations if cost-effective carbon sinks are actively discouraged by enduring doubt over the durability and predictability of climate policy.

A lot of faith seems to have been placed in achieving a 'goldilocks' level of removals that meets the amorphous criteria of "balancing the need for firms to transition to low emissions practices with a need to keep overall costs to the economy manageable".

It is hard to see how forest planting does not count as a "low emissions practice", given it has negative emissions.

We recommend officials revisit their over-supply analysis

Imposing material costs on the economy based on a flimsy problem definition that doesn't stand up to real-world scrutiny would be deeply concerning. We recommend officials press pause on this consultation until they:

(i) Re-examine the forestry over-supply 'problem' with more sophisticated, realistic and accurate models.

(ii) Empirically analyse the macroeconomic, industry, regional, household and Māori impacts of any alternative ETS settings for forestry.

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Appendix A Industry list

MDG-NZ sector	2020 Input-output table industry	MDG-NZ sector	2020 Input-output table industry
Crops	HorticFruit *BrdAcreCrop*	**TransportEq**	TransEquMan
SheepBeef	*Sheep* *BeefCattle*	**MachryOthEq**	MachineryMan ElectPrdMan
DairyFarming	DairyCattle	**FurnOthManu**	FurnitureMan OthMan
OthLivestock	OthLivestock	**HydroElec**	*HydroElec*
ForestryLog	ForestLog	**GeothermElec**	*GeothermElec*
FishingAqua	FishingAqua	**WindElec**	*WindElec*
AgrForFshSup	AgForFishSvc	**SolarElec**	*SolarElec*
CoalCokeTar	CoalCokeTar	**CoalElec**	*CoalElec*
CrudeOil	*CrudeOil*	**GasElec**	*GasElec*
NaturalGas	*NaturalGas*	**OilElec**	*OilElec*
OthMining	MetNonMetMin MiningSupSvc	**BiomassElec**	*BiomassElec*
Meat	MeatMan	**Electricity**	*ElectricDist*
Seafood	SeafoodProc	**Gas**	*Gas*
Dairy	DairyMan	**WaterSewDrn**	*Water* Sewerage
OthFood	OthFoodMan	**Waste**	Waste
BvrgTobacco	BevTobMan	**Construction**	ResidConst NonResConst EngineerSvc ConstructSvc
TextClthFtwr	TexLeathMan ClthFootwMan	**Wholesale**	BasicMatWS MachEquipWS MotorVehWS GrocLiqTobWS OthWS
WoodPrd	WoodProdMan	**Retail**	MotorVehRT FuelRT FoodRT SpecFoodRT FurnElecHwRT RecCloFwPaRT DeptStoreRT PharmOthRT NonStoreRT
PaperPrd	PaperProdMan	**AccomFoodSvc**	AccommSvc FoodBevSvc
Printing	Printing	**RoadFrgtTran**	*RoadFrgtTran*
Petrol	*Petrol*	**RoadPassTran**	*RoadPassTran*
Diesel	*Diesel*	**RailFrgtTran**	*RailFrgtTran*
JetFuelAvGas	*JetFuelAvGas*	**RailPassTran**	*RailPassTran*
FuelOil	*FuelOil*	**WaterTran**	*ShipFrgtTran* *ShipPassTran*

MDG-NZ sector	2020 Input-output table industry	MDG-NZ sector	2020 Input-output table industry
OthPetProd	*OthPetProd*	**AirTran**	*AirFrgtTran* *AirPassTran*
Ethanol	*BioEthanol* *AdvEthanol*	**OthTranSvc**	OthTran PostCourSvc TranSupSvc WHStorageSvc
BioDiesel	*BioDiesel* *AdvDiesel*	**InfoMediaSvc**	Publishing FilmSoundRec BcstInterPub
AdvAviatFuel	*AdvAviatFuel*	**TelecomIntrn**	Telecom InternetData LibInfoSvc
AdvMarFuel	*AdvMarFuel*	**FinanInsur**	BankingFinan LifeInsurnce HealthGenIns SuperPension AuxFinInsSvc
BiomassFuel	*BiomassFuel*	**RentHireLic**	RentHireSvc NonFinAssLse
Hydrogen	*Hydrogen*	**PropREstSvc**	ResPropOp NonResPropOp REstateSvc
LightVehFuel	*LightVehFuel*	**OwnOccProp**	OwnOccPropOp
HeavyVehFuel	*HeavyVehFuel*	**PrfSciTchSvc**	SciArcEngSvc LegalAccSvc AdvManSvc VetOthPrfSvc CompDesSvc
AviationFuel	*AviationFuel*	**AdminSupSvc**	TravTourSvc EmpAdmSvc BldingSupSvc
MarineFuel	*MarineFuel*	**LocGovAdm**	LocGovAdm
Chemicals	BasicChemMan FertPestMan OthChemMan	**CenGovAdmSvc**	CentGovSvc Defence PubOrdRegSvc
PolymrRubber	PlyRubPrdMan	**Education**	PreschoolEdu SchoolEdu TertiaryEdu AdultCommEdu
NonMetMin	NonMetPrdMan	**HealthSocSvc**	Hospitals MedHealthSvc ResCareSocAs
PrimMetalPrd	PrmMetPrdMan	**ArtsRecOthSvc**	HeritageArts SportRecSvc Gambling RepairMaint PerSvcHHStf RelCivilProf
FabMetalPrd	FabMetPrdMan		

Note: italicised industries are those we added to/split out from the 109 IO table industries

Appendix B The MDG-NZ model

Introducing MDG-NZ

We use an advanced dynamic CGE model of the New Zealand economy for this project. Titled MDG-NZ, it was built for Sense Partners in late 2019 by Dr Ashley Winston of MacroDyn Group (MDG) LLC, based in Washington DC (now Phylleos Inc).

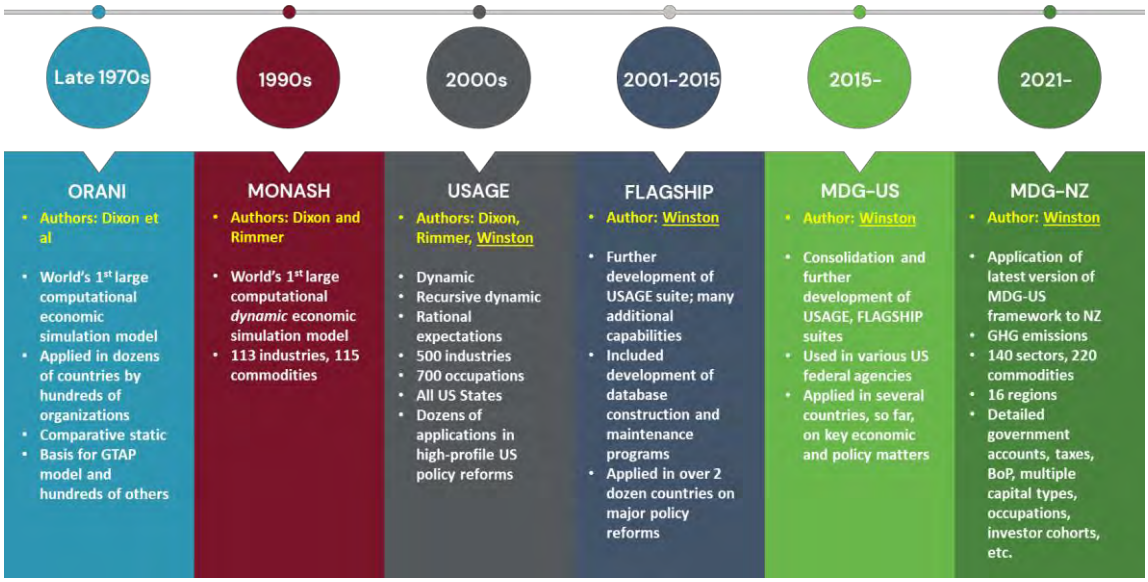
The New Zealand CGE modelling suite is built on the foundation of the path breaking and proven US MDG model. MDG incorporates a wide range of policy modelling innovations created for high-profile projects conducted by MDG's team in a range of countries over the last 25 years.

Versions of the MDG modelling framework continue to be used by governments in several countries, and applications have informed key policy reform and other economic matters in many dozens of countries in addition.

MDG-NZ has a lineage that traces back to the MONASH dynamic CGE model developed by the Centre of Policy Studies, then at Monash University, now at Victoria University, Melbourne.[33] Dr Winston implemented several improvements to the MONASH model as a PhD student under the tutelage of Professor Peter Dixon in the late 1990s/early 2000s.

Dr Winston continued developing dynamic CGE models throughout the next two decades, including the USAGE model of the US economy[34] and the FLAGSHIP[35] suite of models for over 20 countries, before building and continually extending the proprietary MDG suite of models from 2015.

FIGURE 26 40+ YEAR HISTORY OF MDG-NZ



[33] See https://www.copsmodels.com/monmod.htm. Full documentation is in Dixon and Rimmer (2002b).
[34] See https://www.copsmodels.com/usage.htm. Dixon and Rimmer (2002a) has the technical documentation.
[35] See KMPG (2015).

MDG-NZ is built and run in the GEMPACK software suite.[36]

Technical documentation is under development, and a draft is available from the authors on request.

What is a CGE model?

CGE models are commonly used tools for policy analysis. Such models typically consist of:

1. A **database** that represents an economy in a certain year based on input-output (IO) tables. The database specifies the interactions and relationships between various economic agents including firms, workers, households, the government and overseas markets.
2. Behavioural **parameters** governing agents' responses to relative price changes (e.g. elasticities).[37]
3. A **system of equations** that define the model specification or theory, which is generally based on standard economic assumptions[38], but not necessarily constrained by them (for example, in the always-and-everywhere attainment of equilibrium after shocks are imposed).

From an initial equilibrium where demand equals supply in all factor, final demand and intermediate input markets,[39] the system is then 'shocked' by changing one or more variables that represent a policy change or other change in economic conditions.

By comparing the pre- and post-shock databases, we can then observe the effects of the shock in question in terms of changes to GDP, employment, wages, industry output, etc.

Bringing dynamics into the picture

Static CGE models consider only 'before' and 'after' the policy shock. There is no ability to consider the nature of the adjustment path between equilibria.

A dynamic CGE model allows the user to examine in each intervening period (usually each year) how variables adjust from the time when a shock is implemented to the time when all its effects have worked through the economy (which may be several years).

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[36] See Horridge et al (2018).
[37] We rely on published studies for elasticity estimates to calibrate MDG-NZ. Elasticities are set at values widely understood to be valid in the modelling community and can be replaced by country- or industry-specific estimates where available for specific projects.
[38] These include, for example, consumers maximise their utility subject to their budget constraints; firms maximise their profits by buying intermediate goods and inputs (labour and capital) and selling outputs to other domestic and international firms, households and government; there is a market for each commodity (final and intermediates) and in equilibrium market prices are such that demand equals supply in all input and output markets; and under the standard assumption of constant returns to scale firms earn zero pure profit. Alternative theoretical specifications can be incorporated as required.
[39] This is true in both a theoretical and real-world sense. For example, goods market clear because the macroeconomic accounting used in these models accommodates inventory accumulation (or decumulation), and labour markets allow for structural unemployment and other factors that allow something like a NAIRU to act as the market-clearing condition.

MDG-NZ contains four key **dynamic mechanisms** that link successive years:

1. The deviation in the real wage rate away from its forecast path in year *t* caused by a policy shock equals the deviation in year *t-1* plus a term reflecting the gap in year *t* between the employment deviation and the deviation in labour supply. That is, real wages deviate from the baseline based on the gap between the changes in the labour supply and employment caused by a policy shock.

   Real wages are sticky in the short term, meaning labour market impacts are felt more through changes in employment. Further out in the projection period, employment gradually returns to the baseline, meaning impacts are more commonly seen through real wage changes.

2. Capital at the start of year *t* equals capital at the end of year *t-1*.

   Capital stock in an industry at the end of year *t* equals the capital stock at the start of year *t,* depreciated at a given rate, plus investment in year *t* for that industry.

   Investment in year *t* for an industry is a function of the expected rate of return (i.e. gross operating surplus) in that industry. The expected rate of return is a function of the rental and asset prices of that industry's capital in year *t*, depreciation, taxes on capital, and expected changes in those variables.[40]

3. Net foreign liabilities at the start of year *t* equal net foreign liabilities at the end of year *t-1.* Net foreign liabilities at the end of year *t* equal net foreign liabilities at the start of year *t* plus the current account deficit for year *t.*

   The current account deficit for year *t* is imports less exports plus interest payments for foreign liabilities less exports of royalties, and less net transfers from foreigners to New Zealand residents.

4. Public sector debt at the start of year *t* equals public sector debt at the end of year *t-1*.

   Public sector debt at the end of year *t* equals public sector debt at the start of year *t* plus the public sector deficit for year *t*.

The MDG-NZ model is generally solved in recursive dynamic mode, as this has clear advantages in terms of (for example) realistic behavioural responses that can include errors in expectations.

We can also conduct comparative static analyses of both short- and long-run timeframes, along with (much less frequently) forward-looking or 'rational expectations' dynamic simulations that capture anticipation effects but that impose arguably unrealistic 'clarity of foresight' assumptions on simulation output.

[40] A novel feature of MDG-NZ is the inclusion of "slack capital" capabilities for dynamic projections using nested complementarity relationships. This allows for endogenously determined proportions of productive capital stocks and other "fixed" factors (like land and other natural endowments) to become idle at low rates of return during periods of falling demand. Along with the labour market treatment described above, the modelling suite is capable of more realistic dynamic simulations through the business cycle, tempering a standard dynamic CGE tendency to create unrealistically fast recoveries from downturns in response to low primary factor prices.

Regional module

Our regional database comprises up to 16 regions, with each regional economy consisting of the same 140 industries, producing 220 goods or services.

In a **bottom-up simulation**, regions and industries are linked through inter-regional trade flows, margins and factor flows.

In a **top-down simulation**, there is no inter-regional trade, and national level economic impacts in policy scenarios are apportioned across regions based on each region's share of each 'tradable' national industry. The impacts on locally produced and consumed 'non-tradable' commodities (such as personal services) are driven primarily by changes in regional household incomes.

There is no official IO data available for New Zealand's regional economies. To create our own regional IO tables, we start with the 2020 national level IO table and use Business Demography data from StatsNZ to apportion (in shares) economic activity by industry across New Zealand's regions. Regional GDP (or Gross Regional Product) is consistent with StatsNZ's official estimates.

Each region has a representative household, which maximises utility subject to a budget constraint. Aggregate household spending is a function of aggregate household disposable income in that region. Households purchase goods and services from within their region and imports from other domestic regions and from overseas.

Other end users include other firms, central and local government, investors and the export sector.

Firms minimise costs for a given level of output, substituting between intermediate inputs and factors of production as relative process change. Firms determine their input mix using a nested structure:

- The first nest is a bundle of intermediate inputs and a bundle of primary factor use (land, labour, capital, etc.) using a Leontief (fixed proportions) structure. This means that if output grows by x%, so too does the demand for the bundles of intermediates and factors of production.
- The second level nest determines the mix of intermediate inputs between domestic inputs and inputs imported from overseas; and the split of primary factors across labour, land and capital.
- The third level nest determines where domestic intermediate inputs come from across the 16 regions. It also combines labour inputs across eight occupation types and different types of capital assets (plant, machinery & equipment, transport, residential buildings, non-residential buildings, intangible assets, etc.).

Factors of production are 'sticky' on a regional basis, apart from labour and capital, which can move across regional boundaries based on relative factor prices.

Regional commodities are designated either as 'local' or 'national' products. These are analogous to non-tradeable and tradeable products at the national level.

'Local' goods are not traded a great deal and tend to be produced and consumed locally (e.g. restaurants and personal services such as haircuts). 'National' goods are impacted more by national economic drivers (e.g. manufacturing commodities).

Model closure

The closure of a CGE model refers to the elements that we tell the model about (**exogenous variables**) and those which we want the model to tell us about (**endogenous variables**).

In MDG-NZ the closure is extremely flexible, allowing us to incorporate a wide variety of inputs into simulations depending on the availability of data in a particular country, often including expert speciality forecasts from official or other expert sources.

We can adjust the closure assumptions from year to year, depending on the policy simulations we are considering. There is no need, for example, to assume full employment in all years.

The **deviation or 'policy' simulation** is the run that includes the shocks for the economic or policy experiment itself. The number of shocks can vary from a single shock to dozens or hundreds of shocks.

The results are reported as deviations – that is, as the difference between the baseline rerun results and the policy simulation results for each variable. This enables us to report results that capture only the impact of the experimental shocks themselves.

The policy simulation closure looks much more like a 'standard' economic closure. By this we mean that if we were to write down an economic model's equation in a standard theoretical manner, most of the left-hand side variables would be endogenous in the deviation simulation.[41]

Closure choice, across all simulation types, reflects choices about the economic environment and normally goes beyond a simple assessment of matching exogenous variables with shocks.

[41] There are some exceptions: for example, if a path has been endogenously generated for a certain productivity metric in the forecast, these results might be used as shocks in the deviation simulation if we believe that the nature of the experiment does not lead to additional productivity change. However, sometimes the deviation experiment does require further accommodation of shocks by productivity shifts, in which case we would leave it endogenous and report the difference between the baseline and deviation experiments.

Appendix C Regional heat maps for Scenario 4

FIGURE 27 HEAT MAP FOR SCENARIO 4, 2040

Numbers are percentage point contributions to total regional GDP impacts, relative to baseline in 2040

	Northland	Auckland	Waikato	BoP	Gisborne	Hawke's Bay	Taranaki	Mana-Whang	Wellington	Tasman	Nelson	Marlborough	West Coast	Canterbury	Otago	Southland
Crops	-0.008	-0.001	-0.005	-0.007	-0.023	-0.031	-0.001	-0.006	-0.001	-0.047	0.000	-0.022	-0.002	-0.003	-0.010	-0.008
SheepBeef	-0.018	-0.001	-0.017	-0.005	-0.112	-0.040	-0.011	-0.042	-0.004	-0.030	0.000	-0.016	-0.010	-0.014	-0.032	-0.065
Dairy	-0.047	-0.001	-0.076	-0.024	-0.004	-0.012	-0.069	-0.048	-0.004	-0.032	-0.001	-0.011	-0.105	-0.041	-0.031	-0.125
OthLivestock	-0.006	-0.001	-0.011	-0.006	-0.007	-0.007	-0.009	-0.012	-0.003	-0.015	-0.001	-0.005	-0.010	-0.004	-0.005	-0.006
ForestLog	0.078	0.003	0.038	0.035	0.196	0.043	0.015	0.030	0.006	0.157	0.009	0.034	0.043	0.007	0.020	0.026
FishingAqua	-0.004	-0.001	-0.003	-0.002	-0.004	-0.002	0.000	-0.001	-0.001	-0.005	-0.135	-0.048	-0.004	-0.007	-0.001	-0.010
AgrForFshSup	-0.005	-0.001	-0.006	-0.016	-0.023	-0.015	-0.001	-0.007	-0.002	-0.009	-0.003	-0.025	-0.002	-0.004	-0.007	-0.010
Coal	0.000	0.000	-0.070	-0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-1.353	-0.007	-0.006	-0.109
Oil	0.000	0.000	0.000	0.000	0.000	0.000	0.055	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
NatGas	0.000	0.000	0.000	0.000	0.000	0.000	-1.188	0.000	-0.078	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OthMining	-0.046	-0.024	-0.068	-0.021	-0.027	-0.030	-0.076	-0.027	-0.027	-0.021	-0.017	-0.040	-0.117	-0.026	-0.077	-0.047
Meat	-0.004	-0.003	-0.009	-0.003	-0.007	-0.020	-0.020	-0.016	-0.002	-0.001	-0.005	-0.005	-0.011	-0.008	-0.012	-0.034
Seafood	-0.004	-0.002	-0.004	-0.009	-0.006	-0.005	0.000	-0.002	0.000	-0.075	-0.086	-0.075	-0.018	-0.008	-0.001	-0.010
DairyProds	-0.006	-0.002	-0.014	-0.002	-0.002	-0.001	-0.020	-0.007	0.000	-0.005	0.000	0.000	-0.030	-0.008	-0.003	-0.016
OthFood	0.007	0.010	0.011	0.010	0.024	0.022	0.020	0.011	0.006	0.009	0.012	0.026	0.018	0.013	0.006	0.010
BvrgTobacco	0.003	0.009	0.003	0.003	0.011	0.023	0.003	0.003	0.006	0.029	0.008	0.130	0.003	0.005	0.009	0.001
TextClthFtwr	0.002	0.003	0.001	0.001	0.001	0.004	0.002	0.003	0.001	0.001	0.003	0.001	0.002	0.002	0.001	0.002
WoodPrd	0.009	0.002	0.005	0.006	0.004	0.003	0.010	0.002	0.001	0.012	0.006	0.003	0.018	0.003	0.002	0.007
PaperPrd	0.000	-0.006	-0.007	-0.019	0.000	-0.022	0.000	-0.006	-0.001	0.000	0.000	0.000	0.000	-0.003	-0.001	0.000
Printing	0.002	0.005	0.003	0.003	0.004	0.003	0.003	0.003	0.005	0.002	0.004	0.002	0.003	0.004	0.005	0.003
Petrol	-0.067	-0.002	-0.002	-0.005	0.000	0.000	-0.007	0.000	-0.015	0.000	-0.005	0.000	0.000	-0.003	-0.001	-0.002
Diesel	-0.055	-0.002	-0.002	-0.004	0.000	0.000	-0.005	0.000	-0.013	0.000	-0.004	0.000	0.000	-0.002	-0.001	-0.002
JetFuelAvGas	-0.107	-0.003	-0.003	-0.008	0.000	0.000	-0.014	0.000	-0.024	0.000	-0.007	0.000	0.000	-0.004	-0.002	-0.004
FuelOil	-0.026	-0.001	-0.001	-0.002	0.000	0.000	-0.003	0.000	-0.006	0.000	-0.002	0.000	0.000	-0.001	-0.001	-0.001
OthPetProd	-0.064	-0.002	-0.002	-0.005	0.000	0.000	-0.003	0.000	-0.015	0.000	-0.004	0.000	0.000	-0.002	-0.002	-0.002
Ethanol	0.000	0.000	0.000	-0.001	0.000	0.000	-0.003	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
BioDiesel	0.000	0.000	0.000	-0.001	0.000	0.000	-0.003	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
AdvAviatFuel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AdvMarFuel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BiomassFuel	-0.010	0.000	0.000	-0.001	0.000	0.000	-0.001	0.000	-0.002	0.000	-0.001	0.000	0.000	0.000	0.000	0.000
Hydrogen	0.000	-0.001	0.000	-0.001	0.000	0.000	-0.003	-0.001	0.000	-0.001	0.000	0.000	0.000	0.000	0.000	0.000
LightVehFuel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
HeavyVehFuel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AviationFuel	-0.010	0.000	0.000	-0.001	0.000	0.000	-0.001	0.000	-0.002	0.000	-0.001	0.000	0.000	0.000	0.000	0.000
MarineFuel	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Chemicals	-0.083	-0.142	-0.142	-0.209	-0.052	-0.154	-0.148	-0.101	-0.064	-0.079	-0.119	-0.061	-0.107	-0.125	-0.075	-0.120
PolymrRubber	0.001	0.004	0.004	0.002	0.002	0.001	0.003	0.003	0.002	0.000	0.002	0.001	0.000	0.002	0.000	0.001
NonMetMin	-0.052	-0.030	-0.034	-0.028	-0.013	-0.015	-0.015	-0.023	-0.016	-0.031	-0.009	-0.019	-0.015	-0.035	-0.020	-0.019
PrimMetalPrd	-0.028	-0.068	-0.072	-0.026	-0.011	-0.029	-0.099	-0.037	-0.022	-0.009	-0.022	-0.021	-0.007	-0.048	-0.043	-0.370
FabMetalPrd	-0.008	-0.008	-0.010	-0.009	-0.004	-0.009	0.001	-0.010	-0.004	-0.003	-0.006	-0.008	-0.001	-0.008	-0.008	-0.007
TransportEq	0.003	0.008	0.005	0.004	0.002	0.004	0.008	0.003	0.003	0.002	0.006	0.005	0.003	0.007	0.003	0.004
MachryOthEq	0.013	0.021	0.019	0.016	0.007	0.013	0.036	0.016	0.009	0.014	0.016	0.010	0.022	0.023	0.009	0.015
FurnOthManu	0.001	0.002	0.001	0.001	0.000	0.002	0.004	0.001	0.001	0.001	0.002	0.001	0.007	0.001	0.001	0.001
HydroElec	0.014	0.064	0.236	0.435	0.004	0.016	0.046	0.074	0.054	0.009	0.000	0.000	0.013	0.077	0.183	0.021
GeothermElec	-0.001	-0.008	-0.009	-0.004	0.000	-0.001	-0.010	-0.005	-0.004	-0.001	0.000	0.000	-0.003	-0.007	-0.006	-0.005
WindElec	0.001	0.005	0.019	0.036	0.000	0.001	0.003	0.006	0.004	0.001	0.000	0.000	0.001	0.006	0.015	0.001
SolarElec	0.000	0.000	0.001	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000
CoalElec	-0.002	-0.010	-0.028	-0.049	0.000	-0.001	-0.008	-0.009	-0.007	-0.001	0.000	0.000	-0.003	-0.011	-0.021	-0.004
GasElec	-0.005	-0.032	-0.093	-0.154	0.000	-0.004	-0.050	-0.031	-0.024	-0.003	0.000	0.000	-0.009	-0.036	-0.070	-0.013
OilElec	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BiomassElec	-0.004	-0.003	-0.004	-0.006	-0.001	-0.003	-0.002	-0.003	-0.002	-0.003	-0.001	-0.005	-0.002	-0.003	-0.004	-0.002
Electricity	-0.024	-0.004	-0.003	0.000	0.000	-0.009	-0.024	-0.004	-0.007	-0.004	0.000	-0.019	-0.019	-0.006	-0.002	-0.020
Gas	-0.012	-0.024	-0.023	-0.024	-0.002	-0.020	-0.038	-0.023	-0.037	-0.012	-0.002	-0.005	-0.002	-0.013	-0.015	-0.006
WaterSewDrn	-0.004	-0.006	-0.004	-0.003	-0.003	-0.007	-0.009	-0.004	-0.008	-0.002	0.000	0.000	-0.002	-0.002	-0.003	-0.003
Waste	-0.024	-0.017	-0.016	-0.016	-0.006	-0.018	-0.014	-0.012	-0.012	-0.016	-0.012	-0.026	-0.019	-0.016	-0.014	-0.011
Construction	-0.098	-0.132	-0.097	-0.048	0.020	-0.073	-0.788	-0.050	-0.075	-0.010	-0.132	-0.051	-0.545	-0.127	-0.072	-0.162
Wholesale	-0.010	-0.057	-0.016	-0.007	0.012	-0.007	-0.055	-0.004	-0.004	0.009	-0.033	0.002	-0.042	-0.027	-0.004	-0.054
Retail	0.024	-0.013	0.015	0.033	0.051	0.021	-0.051	0.035	0.025	0.064	-0.016	0.039	-0.107	0.000	0.033	-0.046
AccomFoodSvc	0.065	0.040	0.056	0.066	0.051	0.057	0.038	0.057	0.059	0.091	0.050	0.077	0.056	0.046	0.106	0.044
RoadFrgtTran	-0.021	-0.015	-0.018	-0.022	-0.022	-0.020	-0.008	-0.019	-0.011	-0.027	-0.013	-0.018	-0.014	-0.018	-0.020	-0.027
RoadPassTran	-0.003	-0.002	-0.003	-0.003	-0.004	-0.003	-0.001	-0.003	-0.002	-0.005	-0.002	-0.003	-0.002	-0.003	-0.003	-0.004
RailFrgtTran	-0.001	-0.003	-0.002	-0.002	-0.001	-0.002	-0.001	-0.003	-0.003	0.000	-0.002	-0.003	-0.003	-0.002	-0.002	-0.002
RailPassTran	0.000	-0.001	-0.001	0.000	0.000	0.000	0.000	-0.001	-0.002	0.000	0.000	-0.001	-0.002	0.000	0.000	-0.001
WaterTran	-0.002	-0.004	-0.001	-0.003	-0.002	-0.003	-0.001	-0.001	-0.013	-0.007	-0.003	-0.016	-0.001	-0.003	-0.002	-0.003
AirTran	-0.008	-0.261	-0.013	-0.028	-0.026	-0.074	-0.031	-0.025	-0.097	-0.008	-0.260	-0.044	-0.183	-0.189	-0.095	-0.040
OthTranSvc	-0.005	-0.007	-0.003	-0.012	-0.009	-0.009	0.012	-0.005	-0.005	-0.003	-0.008	-0.009	0.007	-0.007	-0.010	-0.002
InfoMediaSvc	0.006	0.007	0.006	0.009	0.022	0.006	-0.006	0.009	0.011	0.005	0.005	0.007	-0.012	0.005	0.018	0.002
TelecomIntrn	0.002	0.004	0.005	0.002	0.002	0.002	-0.004	0.003	0.019	0.003	0.001	0.002	-0.002	0.006	0.003	-0.001
FinanInsur	0.018	0.044	0.022	0.038	0.027	0.031	-0.020	0.029	0.105	0.026	0.014	0.027	-0.020	0.025	0.031	-0.001
RentHireLic	0.010	-0.027	-0.001	0.014	0.016	0.008	-0.002	0.013	0.009	0.010	-0.035	0.011	-0.138	-0.013	0.009	-0.013
PropREstSvc	0.059	0.018	0.046	0.075	0.128	0.057	-0.090	0.073	0.069	0.075	0.029	0.093	-0.071	0.043	0.071	-0.031
OwnOccProp	0.060	0.024	0.048	0.076	0.111	0.066	-0.057	0.077	0.074	0.116	0.027	0.090	-0.123	0.035	0.079	-0.027
PrfSciTchSvc	0.006	-0.040	0.014	0.037	0.065	0.023	-0.158	0.033	0.064	0.052	-0.025	0.038	-0.085	-0.006	0.037	-0.035
AdminSupSvc	0.001	-0.009	0.000	0.002	0.006	0.001	-0.013	0.003	0.004	0.008	-0.006	0.009	-0.014	-0.003	0.005	-0.004
LocGov	0.000	0.000	0.000	0.000	0.000	0.000	0.002	-0.001	0.000	0.000	0.000	-0.001	0.002	0.000	0.000	0.000
CenGov	0.004	0.003	0.003	0.001	0.001	0.002	0.007	0.004	0.006	0.001	0.003	0.002	0.006	0.002	0.001	0.003
Education	0.061	0.048	0.057	0.057	0.068	0.054	0.040	0.082	0.064	0.050	0.046	0.037	0.032	0.050	0.079	0.040
HealthSocSvc	0.030	0.009	0.019	0.025	0.038	0.021	-0.002	0.027	0.022	0.021	0.016	0.020	-0.020	0.013	0.024	0.000
ArtRecOthSvc	0.019	-0.021	0.012	0.029	0.034	0.015	-0.021	0.032	0.026	0.038	-0.027	0.024	-0.172	-0.004	0.027	-0.025
Total	-0.383	-0.665	-0.244	0.222	0.536	-0.147	-2.855	0.081	0.036	0.339	-0.746	0.134	-3.169	-0.482	0.096	-1.328

SOURCE: MDG-NZ MODELLING

FIGURE 28 HEAT MAP FOR SCENARIO 4, 2050

Numbers are percentage point contributions to total regional GDP impacts, relative to baseline in 2050

	Northland	Auckland	Waikato	BoP	Gisborne	Hawke's Bay	Taranaki	Mana-Whang	Wellington	Tasman	Nelson	Marlborough	West Coast	Canterbury	Otago	Southland
Crops	-0.046	-0.007	-0.03	-0.04	-0.146	-0.188	-0.011	-0.037	-0.006	-0.289	-0.002	-0.131	-0.012	-0.02	-0.059	-0.052
SheepBeef	-0.068	-0.004	-0.065	-0.018	-0.419	-0.154	-0.043	-0.162	-0.016	-0.112	-0.001	-0.061	-0.039	-0.054	-0.12	-0.255
Dairy	-0.197	-0.005	-0.317	-0.097	-0.018	-0.05	-0.307	-0.201	-0.015	-0.134	-0.002	-0.046	-0.455	-0.167	-0.128	-0.532
OthLivestock	-0.018	-0.004	-0.033	-0.016	-0.021	-0.021	-0.027	-0.035	-0.009	-0.043	-0.003	-0.014	-0.031	-0.013	-0.014	-0.017
ForestLog	1.626	0.054	0.796	0.74	3.962	0.907	0.316	0.624	0.131	3.236	0.203	0.714	0.91	0.157	0.43	0.547
FishingAqua	-0.01	-0.002	-0.008	-0.006	-0.012	-0.005	-0.001	-0.001	-0.002	-0.015	-0.351	-0.13	-0.01	-0.018	-0.003	-0.027
AgrForFshSup	0.023	0.005	0.025	0.059	0.066	0.063	0.018	0.028	0.007	0.029	0.013	0.096	0.022	0.016	0.026	0.057
Coal	0	0	-0.165	-0.002	0	0	0	0	0	0	0	0	-3.161	-0.017	-0.015	-0.256
Oil	0	0	0	0	0	0	0.135	0	-0.002	0	0	0	0	0	0	0
NatGas	0	-0.001	0	0	0	0	-2.596	0	-0.171	0	0	0	0	0	0	0
OthMining	-0.136	-0.066	-0.197	-0.06	-0.088	-0.087	-0.222	-0.08	-0.076	-0.067	-0.047	-0.114	-0.336	-0.071	-0.219	-0.137
Meat	-0.013	-0.008	-0.028	-0.008	-0.021	-0.063	-0.062	-0.05	-0.008	-0.003	-0.016	-0.014	-0.033	-0.025	-0.035	-0.108
Seafood	-0.018	-0.008	-0.015	-0.038	-0.032	-0.019	0	-0.007	-0.002	-0.345	-0.314	-0.29	-0.087	-0.031	-0.006	-0.042
DairyProds	-0.023	-0.008	-0.05	-0.009	-0.007	-0.003	-0.078	-0.024	-0.001	-0.016	-0.001	-0.001	-0.115	-0.028	-0.011	-0.06
OthFood	0.01	0.018	0.017	0.014	0.011	0.031	0.04	0.015	0.009	0.007	0.021	0.036	0.035	0.021	0.009	0.018
BvrgTobacco	0.006	0.018	0.006	0.006	0.011	0.042	0.007	0.005	0.013	0.039	0.016	0.24	0.007	0.011	0.018	0.002
TextClthFtwr	0	0.003	0	0	-0.003	0	0.004	0	0.001	-0.002	0.003	0	0.004	0.002	0	0.002
WoodPrd	0.1	0.023	0.062	0.084	0.04	0.041	0.064	0.036	0.018	0.132	0.068	0.042	0.124	0.038	0.025	0.071
PaperPrd	0	-0.008	-0.011	-0.031	0	-0.036	0	-0.01	-0.002	0	0	0	0	-0.005	-0.002	0
Printing	0.005	0.014	0.007	0.006	0.006	0.007	0.007	0.007	0.013	0.004	0.009	0.004	0.009	0.01	0.012	0.007
Petrol	-0.207	-0.006	-0.006	-0.015	0	0	-0.021	0	-0.045	0	-0.013	0	0	-0.007	-0.004	-0.008
Diesel	-0.169	-0.005	-0.005	-0.012	0	0	-0.016	0	-0.037	0	-0.011	0	0	-0.006	-0.004	-0.006
JetFuelAvGas	-0.281	-0.008	-0.008	-0.02	0	0	-0.037	0	-0.062	0	-0.019	0	0	-0.01	-0.006	-0.011
FuelOil	-0.066	-0.002	-0.002	-0.005	0	0	-0.008	0	-0.014	0	-0.004	0	0	-0.002	-0.001	-0.002
OthPetProd	-0.309	-0.008	-0.008	-0.023	0	0	-0.019	0	-0.065	0	-0.018	0	0	-0.01	-0.007	-0.01
Ethanol	0	-0.001	0	-0.001	0	0	-0.006	-0.002	0	-0.002	0	0	0	0	0	0
BioDiesel	0	-0.001	0	-0.001	0	0	-0.005	-0.001	0	-0.002	0	0	0	0	0	0
AdvAviatFuel	0	0	0	0	0	0	-0.001	0	0	0	0	0	0	0	0	0
AdvMarFuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BiomassFuel	-0.023	-0.001	-0.001	-0.002	0	0	-0.003	0	-0.005	0	-0.002	0	0	-0.001	0	-0.001
Hydrogen	0	-0.001	-0.001	-0.002	0	0	-0.008	-0.003	0	-0.003	0	0	0	0	0	0
LightVehFuel	-0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HeavyVehFuel	-0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
AviationFuel	-0.029	-0.001	-0.001	-0.002	0	0	-0.004	0	-0.006	0	-0.002	0	0	-0.001	-0.001	-0.001
MarineFuel	-0.001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Chemicals	-0.224	-0.374	-0.387	-0.559	-0.145	-0.42	-0.405	-0.277	-0.172	-0.214	-0.309	-0.163	-0.29	-0.333	-0.203	-0.33
PolymrRubber	0.001	0.009	0.006	0.002	-0.006	0.001	0.007	0.004	0.003	0	0.004	0.001	0.001	0.005	0.001	0.002
NonMetMin	-0.143	-0.078	-0.094	-0.075	-0.038	-0.041	-0.04	-0.065	-0.042	-0.087	-0.023	-0.051	-0.039	-0.093	-0.053	-0.051
PrimMetalPrd	-0.076	-0.183	-0.199	-0.071	-0.032	-0.082	-0.273	-0.104	-0.062	-0.025	-0.057	-0.057	-0.019	-0.131	-0.117	-1.031
FabMetalPrd	-0.029	-0.022	-0.031	-0.029	-0.018	-0.029	0.003	-0.032	-0.013	-0.013	-0.016	-0.025	-0.001	-0.023	-0.023	-0.021
TransportEq	0.007	0.022	0.011	0.008	0.001	0.009	0.021	0.008	0.007	0.002	0.016	0.012	0.008	0.019	0.007	0.011
MachryOthEq	0.025	0.061	0.044	0.034	-0.001	0.029	0.103	0.037	0.025	0.008	0.046	0.022	0.063	0.064	0.023	0.042
FurnOthManu	0.001	0.005	0.001	0.001	-0.002	0.003	0.01	0.002	0.002	-0.002	0.004	0.001	0.02	0.004	0.001	0.004
HydroElec	0.038	0.17	0.625	1.211	0.012	0.04	0.116	0.192	0.144	0.024	0	0.001	0.034	0.202	0.488	0.048
GeothermElec	-0.004	-0.029	-0.055	-0.058	0	-0.004	-0.033	-0.023	-0.019	-0.002	0	0	-0.01	-0.029	-0.039	-0.017
WindElec	0.002	0.012	0.046	0.092	0	0.002	0.007	0.013	0.009	0.001	0	0	0.002	0.014	0.036	0.003
SolarElec	0	0.001	0.003	0.006	0	0	0	0.001	0.001	0	0	0	0	0.001	0.003	0
CoalElec	-0.003	-0.018	-0.049	-0.089	0	-0.002	-0.014	-0.016	-0.012	-0.002	0	0	-0.004	-0.019	-0.038	-0.007
GasElec	-0.012	-0.072	-0.203	-0.35	0	-0.01	-0.107	-0.067	-0.054	-0.007	0	0	-0.019	-0.079	-0.155	-0.029
OilElec	0	0	0	0	0	0	0.001	0	0	0	0	0	0	0	0	0
BiomassElec	-0.008	-0.007	-0.009	-0.012	-0.002	-0.006	-0.004	-0.005	-0.005	-0.005	-0.002	-0.009	-0.005	-0.006	-0.008	-0.004
Electricity	-0.06	-0.009	-0.007	0.001	0	-0.022	-0.061	-0.011	-0.017	-0.009	0	-0.048	-0.045	-0.015	-0.005	-0.053
Gas	-0.023	-0.046	-0.042	-0.046	-0.004	-0.037	-0.071	-0.043	-0.07	-0.022	-0.004	-0.01	-0.004	-0.025	-0.029	-0.01
WaterSewDrn	-0.008	-0.012	-0.008	-0.007	-0.007	-0.015	-0.018	-0.009	-0.016	-0.005	-0.001	-0.001	0	-0.005	-0.006	-0.006
Waste	-0.057	-0.038	-0.037	-0.037	-0.013	-0.04	-0.031	-0.027	-0.027	-0.035	-0.027	-0.059	-0.042	-0.036	-0.033	-0.025
Construction	-0.23	-0.358	-0.227	-0.071	0.145	-0.169	-1.754	-0.12	-0.193	0.07	-0.368	-0.142	-1.284	-0.352	-0.195	-0.423
Wholesale	-0.029	-0.167	-0.046	-0.014	0.036	-0.024	-0.129	-0.019	-0.017	0.024	-0.101	-0.003	-0.104	-0.084	-0.018	-0.153
Retail	0.047	-0.063	0.025	0.083	0.14	0.043	-0.122	0.074	0.044	0.164	-0.082	0.071	-0.271	-0.03	0.059	-0.142
AccomFoodSvc	0.158	0.095	0.141	0.166	0.118	0.141	0.106	0.141	0.145	0.212	0.118	0.184	0.16	0.111	0.259	0.112
RoadFrgtTran	-0.043	-0.025	-0.035	-0.044	-0.06	-0.039	-0.005	-0.037	-0.019	-0.067	-0.022	-0.034	-0.014	-0.032	-0.037	-0.045
RoadPassTran	-0.014	-0.008	-0.013	-0.013	-0.018	-0.012	-0.004	-0.013	-0.007	-0.022	-0.006	-0.011	-0.007	-0.01	-0.012	-0.016
RailFrgtTran	-0.004	-0.007	-0.004	-0.006	-0.004	-0.005	-0.002	-0.007	-0.008	-0.001	-0.005	-0.009	-0.009	-0.004	-0.005	-0.005
RailPassTran	-0.001	-0.003	-0.003	-0.001	0	-0.001	-0.001	-0.005	-0.005	0	0	-0.005	-0.007	-0.001	-0.001	-0.002
WaterTran	-0.006	-0.013	-0.004	-0.01	-0.008	-0.008	-0.003	-0.004	-0.039	-0.025	-0.01	-0.049	-0.003	-0.009	-0.007	-0.008
AirTran	-0.022	-0.709	-0.038	-0.078	-0.075	-0.209	-0.087	-0.072	-0.272	-0.023	-0.7	-0.123	-0.511	-0.521	-0.263	-0.115
OthTranSvc	-0.024	-0.015	-0.011	-0.048	-0.065	-0.037	0.036	-0.016	-0.014	-0.022	-0.017	-0.031	0.023	-0.019	-0.032	-0.005
InfoMediaSvc	0.014	0.016	0.015	0.024	0.053	0.016	-0.008	0.022	0.029	0.013	0.01	0.017	-0.02	0.013	0.045	0.007
TelecomIntrn	0.004	0.011	0.013	0.007	0.006	0.007	-0.007	0.008	0.051	0.008	0.001	0.004	-0.005	0.015	0.008	-0.003
FinanInsur	0.046	0.1	0.059	0.108	0.078	0.08	-0.034	0.073	0.264	0.071	0.031	0.066	-0.045	0.057	0.077	-0.007
RentHireLic	0.025	-0.077	0	0.039	0.039	0.019	0.006	0.032	0.018	0.018	-0.097	0.019	-0.325	-0.04	0.019	-0.031
PropREstSvc	0.159	0.019	0.12	0.213	0.401	0.145	-0.176	0.177	0.158	0.222	0.032	0.218	-0.154	0.077	0.165	-0.086
OwnOccProp	0.153	0.035	0.117	0.208	0.316	0.159	-0.118	0.18	0.168	0.314	0.037	0.206	-0.288	0.064	0.181	-0.09
PrfSciTchSvc	0.014	-0.123	0.048	0.128	0.202	0.067	-0.337	0.088	0.158	0.154	-0.085	0.086	-0.193	-0.03	0.09	-0.091
AdminSupSvc	0.003	-0.029	-0.002	0.01	0.017	-0.001	-0.032	0.006	0.008	0.02	-0.019	0.016	-0.035	-0.013	0.009	-0.012
LocGov	-0.002	0	-0.002	-0.003	-0.005	-0.002	0.005	-0.003	-0.002	-0.003	0	-0.002	0.004	-0.001	-0.002	0
CenGov	0	0.007	0.002	-0.002	-0.014	0	0.019	-0.001	0.01	-0.004	0.008	-0.001	0.017	0.005	0	0.006
Education	0.146	0.118	0.143	0.14	0.15	0.135	0.108	0.206	0.162	0.112	0.112	0.089	0.086	0.124	0.196	0.103
HealthSocSvc	0.059	0.013	0.036	0.055	0.074	0.041	0.003	0.055	0.047	0.04	0.023	0.038	-0.046	0.022	0.047	-0.009
ArtRecOthSvc	0.05	-0.07	0.035	0.094	0.106	0.043	-0.044	0.082	0.055	0.107	-0.089	0.057	-0.416	-0.025	0.062	-0.068
Total	**0.084**	**-1.881**	**-0.054**	**1.508**	**4.706**	**0.23**	**-6.253**	**0.527**	**0.071**	**3.403**	**-2.071**	**0.606**	**-6.965**	**-1.399**	**0.38**	**-3.378**

SOURCE: MDG-NZ MODELLING

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