Economic impacts of removing NZ ETS transitional measures

A Computable General Equilibrium analysis

NZIER final report to Ministry for the Environment

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Authorship

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Key points

We were asked to model the impacts of removing some ETS transitional measures by 2020

The Ministry for the Environment (MfE) asked us to estimate the potential economic impacts of removing the existing Emissions Trading Scheme (ETS) 1-for-2 emissions unit surrender obligation and the $25 fixed price option.

Reflecting the phased approach to the ETS submissions, analysing changes to other transitional measures (for example, adjusting free allocation of units to emissions-intensive and trade exposed industries) and any potential inclusion of the agriculture sector were out of scope.

Our CGE model considers snapshots of before and after removing the transitional measures; but no adjustment paths

We updated our CGE database, which contains 105 industries and 206 sectors, by projecting the macroeconomy out to 2020 and imposing on the model emissions projections from New Zealand's Second Biennial Report to the UNFCCC, augmented with forestry projections from the Ministry for Primary Industries (MPI). This database update included a continuation of historical technological changes that drive emissions efficiency.[1]

We then 'shocked' the database using a number of scenarios to simulate the removal of transitional measures at different domestic emissions prices. This reflects uncertainty over the price path of emissions units. The results presented here show the differences between the pre- and post-shock situations. There is no dynamic element to the model, so no time path of adjustment.

Removing the 1 for 2 surrender obligation imposes a small cost on the economy as a whole…

Table 1 Macroeconomic results of removing the 1 for 2 obligation

% change from baseline where obligation remains in place at that emissions price, 2020

Measure	Low price ($10/tonne)	Medium price ($25/tonne)	High price ($50/tonne)
GDP	-0.0	-0.1	-0.2
GNDI	-0.0	-0.1	-0.2
Real wages	-0.2	-0.4	-0.8
Consumption	0.0	-0.1	-0.2
Imports	-0.1	-0.2	-0.4
Exports	0.0	0.0	0.0
Gross emissions	-0.3	-0.6	-1.1
Net emissions	-0.3	-0.7	-1.5

Source: NZIER

1 Longer term behavioural changes that might reduce emissions further are not likely within the time horizon of this modelling, but any significant technological breakthroughs between now and 2020 would reduce the economic costs of removing the transitional measures reported here. The same applies to any 'disruptive technology' that might materially affect New Zealand's economic structure or emissions profile, although we think this is unlikely to occur by 2020.

GDP and GNDI fall by 0.1% or around $267 million under the medium market price assumption of $25/tonne. This equates to around 8 hours' worth of GDP in 2020. Real wages fall, leading to a subsequent reduction in household consumption and import volumes. The lower (higher) the emissions price, the smaller (larger) the economic impacts of removing the 1 for 2 obligation.

At current prices, removing the $25 fixed price option may be costless…

At current low emissions prices, the $25/tonne fixed price option has not been adopted in any meaningful way. If emissions prices were to stay low, removal of the $25/tonne fixed price option would therefore have no material impact as it does not act as a binding cap.

… but it might impose costs by 2020 if the supply of NZUs tightens

By 2020 however, the $25/tonne fixed price might be acting as a cap on the market price of New Zealand Units (NZUs) if the supply conditions tighten and NZU prices increase.

In this case, removing the fixed price would impose a cost on the economy:

- If the market emissions price was to rise from $25/tonne to $50/tonne after removal of this transition measure, real GDP would fall by 0.1% or $267 million if the 1 for 2 surrender obligation was still in place;
- Real GDP would fall by 0.2% or $539 million if the 1 for 2 surrender obligation had already been removed.

Overall macroeconomic impacts from removing the transition measures are relatively modest…

These small macroeconomic effects are to be expected as many industries are still facing a lower effective emissions price due to the free allocation of emissions units, which has not yet started to be phased out. While these firms will face the cost of emissions at the margin, the protection afforded by free allocation reduces the pressure they face to raise output prices and cut production.

…but some industries are more affected than others

There is a move from non-renewable to renewable electricity generation as the relative prices tilt in favour of renewables. Under the $25 emissions price scenario, removing the 1 for 2 measure sees non-renewable power industry value-added (GDP) fall by around 6.4% (around $46 million) from its 2020 baseline.

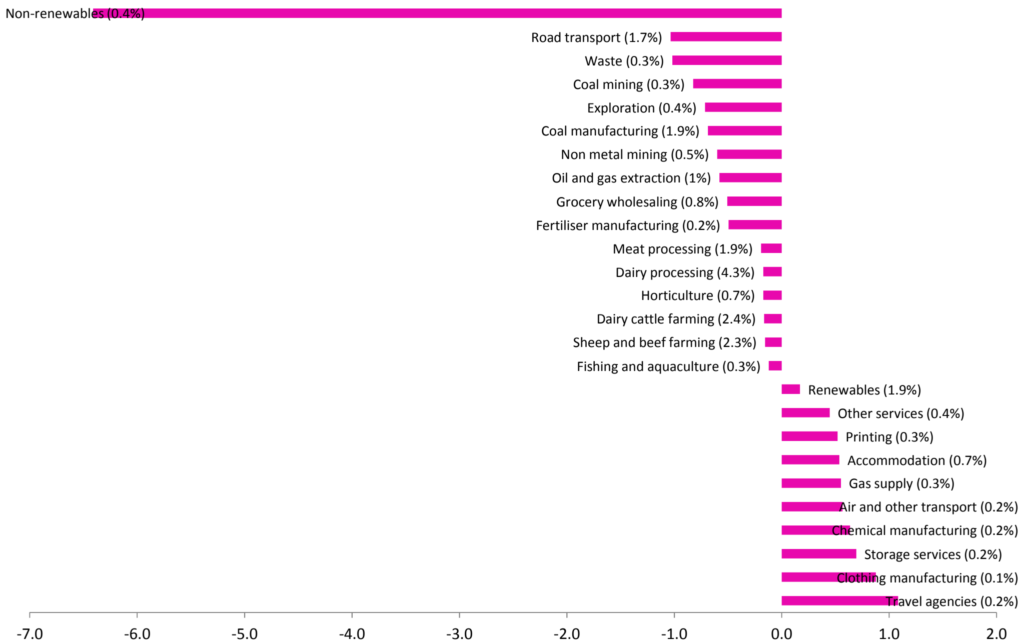
On-farm activities and supporting agricultural goods and services sectors are negatively affected, driven in large part by lower demand from the downstream energy-intensive food processing sectors (primarily meat and dairy processing) that see their costs increase with the removal of the 1 for 2 obligation.

Other energy-intensive industries such as waste, road transport and mining are also negatively affected. However none of these industries experiences large falls in production under the $25 scenario (see selected industry results in Figure 1).

Tourism-related industries such as accommodation and hospitality benefit from a lowering of the exchange rate and average real wages.

Figure 1 Selected industry impacts from removal of 1 for 2 surrender obligation under medium ($25/tonne) price setting

% change in industry value added (GDP) from baseline, 2020, selected industries only. Percentage in brackets shows size of industry to overall economy



Source: NZIER

Rural regions and those on lower incomes are likely to bear proportionately more of the costs

While we have not explicitly modelled impacts on regions in New Zealand due to time constraints, the costs of removing the transitional measures will be relatively higher in regions which have a high proportion of economic activity in those sectors most affected.[2]

For example, regions with strong mining and oil and gas extraction industries, such as Taranaki (which also has a large dairy industry) and the West Coast, will also likely face higher adjustment costs. The Waikato region will also face relatively higher adjustment costs due to the proportionately larger share of its economy based on non-renewable energy and agriculture. And we would expect regions with a high concentration of dairy cattle, beef and sheep farming such as Canterbury to suffer relatively more.

We have also estimated how the transitional measures might affect different income quintiles of households. The reductions in private consumption (i.e. household spending) are slightly larger – in a relative sense – among the lower (i.e. poorer) quintiles than the upper quintiles. This is due to both the assumed uniform proportionate reductions in household tax rates (businesses provide more revenue to government, which is passed onto households as small tax cuts) and the declining emissions intensity of consumption: as incomes rise, households spend proportionately more on services, which are generally less emission-intensive.

2 More detailed regional modelling that fully takes into account regional economic structures and offsetting effects (e.g. the boost to many services sectors) would be required to validate these inferences.

Impacts on Māori are hard to determine without more detailed analysis

Our model database does not split out Māori businesses and workers, but we know that the non-forestry Māori economy is relatively heavily concentrated in the primary sector, which is relatively more negatively affected by the removal of transitional measures.

However, these negative impacts will be at least partially offset by boosts to Māori enterprises in the renewable energy sector and the tourism sector. The impacts on Māori forestry holdings is difficult to estimate, as much will depend on whether ownership is of pre-1990 forests or post-1989 forests.[3]

Limitations

While we are confident that CGE modelling is the most appropriate tool for this type of macroeconomic analysis, all modelling comes with caveats:

- CGE analysis aims to show the broad direction and magnitude of changes in the economy, rather than being a precise forecasting tool. More detailed sector-specific analysis can also usefully inform decision-making. It is important to see this as an economy-wide analysis first and foremost, and to assess the industry-specific results in this context.
- As agreed with officials, we use a static modelling approach that does not show the adjustment path across time of the economy and its industries.
- Our model is not a detailed forestry-focused one. Given the specific features of the forestry sector, we recommend additional modelling using forestry-specific tools is carried out. The forestry outcomes here are largely – but not entirely – determined outside of the model.[4]
- Since we are looking at removing the transitional measures in 2020, any emissions reductions incentivised by such policy changes that occur post-2020 are not captured here.
- We do not explicitly model endogenous technological change, although our baseline emissions profile does incorporate trends in energy efficiency improvements. If a higher emissions price induces successful innovations that reduce the emissions intensity of sectors, the economic costs of removing the transitional measures would be lower than reported here.
- CGE models are not designed to predict, for example, any disruptive technology shifts that might radically alter the emissions intensity of the New Zealand economy or specific sectors. Such changes would reduce the costs of removing the transitional measures.
- Even out to 2020, there is considerable uncertainty over the likely evolution of emissions prices. We use different price sensitivities to cover a range of possibilities. The higher the emissions price, the larger the economic costs of removing the transitional measures.
- We do not consider in any detail the impact of different outcomes of the international climate change negotiations, or how such outcomes might impact on New Zealand's access to international units after 2020.

[3] More detailed analysis, including additional forestry sector modelling, is required to estimate the net impacts, which will also vary by region due to differences in the composition of the Māori economy around New Zealand.

[4] Forestry is subject to resource reallocation in response to relative price changes for factors of production, intermediate inputs and exchange rates much like any other sector in the model.

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1. Objectives and scope

1.1. Aim

The aim of this report is to estimate the economy-wide and industry-level impacts by 2020 of potential changes in the New Zealand Emissions Trading Scheme (ETS) transitional measures related to:

- the 1 for 2 surrender obligation which allows participants to surrender one New Zealand Unit (NZU) for every two tonnes of emissions
- the $25/tonne fixed price option which allows participants to pay a fixed price of $25/tonne in lieu of an NZU.

This analysis investigates the 2020 impact of removing either or both of the transition measures.

1.2. State of the world in 2020

There is uncertainty about how the market for NZUs will unfold over the next five years to 2020. We therefore consider three possible scenarios for the NZU emissions price in 2020:

1. Low price scenario: NZU price of $10/tonne
2. Medium price scenario: NZU price of $25/tonne
3. High price scenario: NZU price of $50/tonne

We evaluate the removal of the transition measures under each price to provide a detailed picture of the possible 2020 economic impacts. However, despite the current low price of NZUs, the medium price is in the range of emissions prices expected by 2020 when judged by independent market commentators and experts for carbon markets overseas.[5]

1.3. Key features of the current NZ ETS

The current New Zealand ETS is a domestic scheme. It has no international linkages, so NZUs cannot be bought or sold overseas. International units are not eligible for surrender. New Zealand has no obligation to pay a penalty if emissions rise above target levels.[6]

Activity-based free allocation of NZUs is provided to energy-intensive, trade-exposed activities at either 60% (e.g. tomatoes, capsicum and whey powder) or 90% (e.g. iron and steel manufacturing, aluminium smelting, methanol production) of 2005 emissions intensity (see Appendix A).

5 See for example the International Energy Agency 2015, World Energy Outlook 2015. Retrieved from www.worldenergyoutlook.org/ (13 November 2015).

6 This is in contrast to the scenarios considered in previous CGE modelling exercises, e.g. NZIER and Infometrics (2011).

1.4. Assumptions

Our analysis contains a number of simplifying assumptions:

Scenario assumptions

- **2020** was decided as the year to model the potential policy changes. This reduces the impact of near term fluctuations in the business cycle and in commodity prices.
- We do not consider any **phasing out of free allocation** to emissions-intensive trade exposed industries. Free allocation stays at current rates.
- We assume that the rest of the **world does not change its response** to climate change, or its response to trade with New Zealand, on the basis of removal of the NZ ETS transition measures. This means that our assumptions about the rest of the world response to climate change (built into our baseline[7]) do not change as New Zealand domestic policy changes.
- All scenarios are modelled in a world without international trading of emission units. Thus any changes in domestic emissions (including from forestry) that occur in response to changes to the ETS have no implications for how many emission units New Zealand might buy or sell to meet its 2020 target.[8]
- We only **consider the direct price impacts** of the removal of transitional measures, not what happens to emissions prices after the policy change. A full evaluation of this would require an analysis of NZU supply and demand beyond the scope of CGE modelling. We do not consider dynamic adjustments in the supply of NZUs within the market, due to a lack of market information.
- We do not examine the possibility of **negative reputational impacts** and/or green trade barriers on New Zealand's exports that may result from overseas markets perceiving that the ETS is not sufficiently credible to support our clean, green image. Any such damaging preference or policy changes would increase the potential costs to the New Zealand economy.

Input assumptions

- Our **database industry emissions data** was scaled to match that provided by the Ministry of Business, Innovation and Employment (MBIE) and MfE out to 2020.
- Based on data provided by MBIE and MfE, we assume that **there is no coal-based electricity generation** in 2020 in any scenario.
- The structure of the New Zealand economy in our model is **based on the 2006/07 input-output table** from Statistics New Zealand, upscaled to align with current macroeconomic aggregates, and then projected out to 2020 using NZIER's *Quarterly Predictions*. To the extent that the economy has structurally changed (or will change) since 2006/07, we will not have captured those changes fully in our database.

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7 We assume that the 2020 scope and intensity of climate policies amongst our trading partners remain at current 2015 levels.

8 This means that RGNDI results are closer to the GDP number than in previous modelling exercises where offshore payments were required to meet any domestic emissions deficit relative a target.

- The emissions price scenarios (low at $10, medium at $25 and high at $50) are representative of a range of possible outcomes, which are uncertain at this point in time. They are not forecasts, but are used to show how economic impacts of policy adjustments change with the emissions price.

Model assumptions

- We do not model **endogenous technical change** that might occur due to emitters facing a higher emissions price after the removal of the transition measures. This is probably a reasonable assumption given that the emissions price is relatively low, the time period under examination is short and firms are not facing the full cost of their emissions due to free allocation entitlements.[9]
- Our approach to including forestry in the modelling is to **impose 2020 net sequestration on our database.** We consider three possible emissions prices, at $10/tonne, $25/tonne and $50/tonne, with sequestration projections estimated by the Ministry for Primary Industries. The economic impacts of changes to harvesting or processing that might result from the activity that underlies MPI's sequestration projections are not captured within this model.[10]
- In our closure, the long run real rate of return on capital is fixed, and the **capital stock is able to change** in response to relative prices. Assuming an alternative capital closure in a static modelling framework would mean holding the total capital stock fixed out to 2020, which we do not feel is appropriate in this case. Holding the capital stock fixed would reduce the macroeconomic cost of changes in transitional measures.
- Our **static modelling approach** does not examine how the New Zealand economy adjusts on a year by year basis to changes in emissions prices or ETS design features. We use a static model that compares a base case with a snapshot of counterfactual at a given point in time (i.e. 2020).
- Our modelling approach is not forward looking so does not capture all of the benefits of the $25/tonne fixed price option in terms of reducing the **uncertainty around emissions prices**. The latest evidence suggests that the $25/tonne fixed price option has not been taken up in any meaningful levels due to the low current NZU price. This would likely change as the emissions price increases.

Many of these limitations and assumptions could be further explored in future modelling exercises.

[9] Any difference in endogenous technical change caused by a higher carbon prior to 2020 price may impact New Zealand's emissions trajectory and future economic impacts after 2020.

[10] Refer to section 5.5 for a further discussion on forestry. Note that MPI does not project or forecast emissions prices, but instead uses them exogenously to determine potential afforestation outcomes.

2. Methodology

2.1. Computable General Equilibrium modelling

As with previous studies of the ETS, we use a Computable General Equilibrium (CGE) model of the New Zealand economy to examine the impacts of removing some of the transitional measures in 2020.

Our 2009 report provides an overview of what CGE modelling is, along with its strengths and weaknesses. That overview is reproduced here in full in Appendix C, and the following excerpt (NZIER and Infometrics, 2009, p.6) provides a summary:

> *[W]e firmly believe that CGE modelling remains the most appropriate tool for assessing the broad economic effects of climate change mitigation policies in New Zealand. As with any model, CGE models can only be an approximation of the highly complex real economy. CGE models are dependent on the database used, the credibility of the assumptions incorporated into the base case and policy scenarios and the 'closure' framework employed (Concept Economics, 2008, p4).*
>
> *Therefore the results can only ever be indicative. The interpretation of CGE results should centre on their direction (up or down) and broad magnitude (small, medium or large), rather than on the precise point estimates that the model produces. Essentially we are modelling scenarios: such modelling does not predict what will happen in the future. Rather, it is an assessment of what could happen in the future, given the structure of the models and input assumptions (Australian Treasury, 2008, p.16).*
>
> *CGE modelling can usefully be augmented with sector-specific partial equilibrium modelling and other quantitative and qualitative research approaches, particularly in difficult areas such as forestry, to develop a deeper base of knowledge for policy makers. It is outside the scope of this report to undertake such research.*

Households and industry responses to changes in emissions prices

The removal of the transitional measures in this study increases the emissions prices that households and industries face.

In our CGE model, households react to higher emissions prices by changing the mix of the goods and services that they consume in favour of those with lower carbon intensity. For example they may switch from coal heating to gas heating. Available choices reflect existing technologies and existing non-price factors. For instance there is no large scale switch to pure electric vehicles in response to higher emissions prices as there are currently challenges such as range uncertainty and battery life that are barriers to their widespread acceptance.

Households may also spend less on all forms of heating and instead spend more on insulation.

All actions by households have direct and indirect effects on an economy's mix of industries, although these effects are dampened if industries receive free allocation of emission units which enables them to avoid passing the full cost of more expensive inputs onto households. Industries do, however, still face an incentive to alter their own input mix in favour of less carbon-intensive products. For example they may use more wood instead of steel, or replace an oil-fired boiler with a gas one. Again this type of substitution reflects existing technologies.

2.2. Household impacts by income bands

One new addition in this analysis (compared to previous NZ ETS modelling) is the decomposition of household impacts. The household sector is split into income quintiles with different average net tax rates (tax paid on income less Working for Families etc.) and different benefit rates (unemployment and other) for each quintile.

Thus although the model does not fully capture improvements in efficiency from reducing the most distortionary tax rates, it does have some capacity to change household tax rates in response to changes in other fiscal flows, notably revenue from the government's sale of emission units.

Any surplus revenue after payment to foresters for emissions sequestration is assumed to be returned to households via a pro rata reduction in net tax rates. This could be consistent with many combinations of changes in marginal tax rates, tax thresholds, and Working For Families abatement profiles.

2.3. Database

The database for this modelling is based on the interactions of flows within the economy sourced from the New Zealand 2006/07 input-output table. It has been updated to reflect:

- 2020 economic conditions as per NZIER's *Quarterly Predictions* forecasts
- 2020 emissions by industry, derived from MfE's emissions data from New Zealand's Second Biennial Report to the UNFCCC
- 2020 post-1989 forestry sequestration from MPI, based on a $25 emissions price
- ETS free allocation based on current legislation.

Key values from the database in 2020 are shown in Table 2.Table 2 2020 reference data

Nominal dollars, reference $25/tonne emissions price

Metric	2020 level	Source
GDP	$287 billion	NZIER *Quarterly Predictions*
GNDI	$280 billion	NZIER *Quarterly Predictions*
Private consumption	$162 billion	NZIER *Quarterly Predictions*
Gross emissions	82,937kt CO2-e	MfE
Net emissions	69,959kt CO2-e	MfE/MPI

Note: Net emissions are measured using the Kyoto Protocol's Second Commitment Period framework

Source: NZIER, MfE, MPI

3. Scenario design and interpreting results

3.1. Evaluating the removal of the 1 for 2 surrender obligation

We run a total of 6 scenarios designed to evaluate the 2020 impact of removing the 1 for 2 surrender obligation at various 2020 emission price settings. The reference scenarios (1-3) provide the reference 'with' the measure available, at three possible emission prices. We then model the scenarios (4-6) 'without' the 1 for 2 surrender obligation.[11]

Table 3 Scenario description

Run	Description	1 for 2 surrender available?	Market price (faced by forestry)	Effective Non-forestry price
1	Reference – low price	Yes	$10	$5
2	Reference – medium price	Yes	$25	$12.50
3	Reference – high price	Yes	$50	$25
4	Remove 1 for 2 – low price	No	$10	$10
5	Remove 1 for 2 – med price	No	$25	$25
6	Remove 1 for 2 – high price	No	$50	$50

Source: NZIER

Comparing the scenarios 'with' and 'without' the 1 for 2 surrender obligations show the effects of removing the transition measure (Table 4).

Table 4 Comparator scenarios for the removal of the 1 for 2 surrender obligation

Price setting	Reference scenario with the 1 for 2 surrender obligation	Comparator scenario without the 1 for 2 surrender obligation
Low ($10/tonne)	1	4
Medium ($25/tonne)	2	5
High ($50/tonne)	3	6

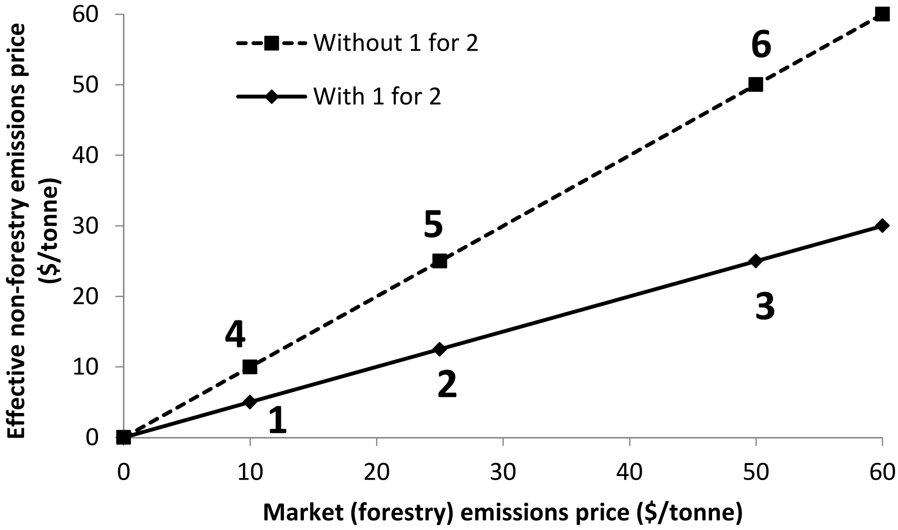
Source: NZIER

[11] Scenarios 3 and 5 are materially the same from a modelling perspective because the non-forestry sectors face the same $25 price. The forestry sector faces a higher price in scenario 3 versus 5 and this affects the net sequestration from forestry that we estimate outside the model.

For non-forestry emitters, the removal of the 1 for 2 surrender obligation doubles the effective emissions price. The forestry sector is exempt from the 1 for 2 option so removing it makes no difference to the effective price faced by forestry (Figure 2).

Figure 2 Impact of removing the 1 for 2 surrender obligation on non-forestry and forestry sectors

Scenarios are numbered 1-6



Source: NZIER

The solid lines in Figure 2 represent the price paths with the 1 for 2 surrender obligation in place. The dashed line represents the price path when the 1 for 2 surrender obligation is removed. Numbers on the figure refer to the scenarios from Table 3.

For example, at the low price setting of $10/tonne, the reference scenario 1 suggests non-forestry emitters face an effective price of $5/tonne. When the 1 for 2 surrender obligation is removed in scenario 4, there is an increase in the effective emissions price to $10/tonne.

Note that in these scenarios, we assume there is no $25 fixed price option in place. The $25/tonne fixed price option acts as a cap on the market price: if it were in place it would limit the market price to $25/tonne.

3.2. Evaluating the removal of the $25 fixed price option

The removal of the $25/tonne fixed price option only becomes important if it is acting as a binding cap on NZU market prices. In such cases, if removed, the underlying market conditions would result in an increase in the market price. At current low NZU prices, this will not occur, but it could do so by 2020.

The pressures on the market price will determine how high the emissions price would rise after removal of the policy. This will subsequently determine the impact of removing the $25/tonne fixed price.

We evaluate two possible scenarios in which the market price rises to $50/tonne when the $25/tonne fixed price cap is removed. If the 1 for 2 surrender obligation is in place, this is the difference between scenarios 3 and 2; if the 1 for 2 surrender obligation is not available, this is the difference between scenarios 5 and 6 (Table 5).[12]

Table 5 Comparator scenarios for the removal of $25/tonne fixed price option if the emissions price rises to $50

Price setting	Reference scenario with the $25/tonne fixed price option	Comparator scenario without the $25/tonne fixed price option
With 1 for 2 obligation	2	3
Without 1 for 2 obligation	5	6

Source: NZIER

12 Note that we are not suggesting that removing fixed price option would result in a $50 emissions price; the resulting emissions price could be higher or lower than this. We are simply comparing the effects of removing the $25 fixed price option in a scenario when the price is materially higher than the cap to understand the relative magnitude of the impacts.

4. How to interpret results

4.1. Scenario modelling

We present the results below as the differences between scenarios in Table 4 and Table 5. This allows us to show the effects of removing the transition measures under different assumptions about the emissions price. The individual scenario results are presented in Appendix B.

4.2. Choice of model outputs

The key model outputs that we report are real Gross Domestic Product (GDP), real Gross National Disposable Income (GNDI), and changes to domestic emissions levels, both gross and net.

GDP measures the value of goods and services produced within New Zealand. GNDI measures total incomes that New Zealand residents receive from both domestic production and net income flows from the rest of the world. Real GNDI is therefore typically a better indicator of welfare or living standards. However in this analysis both GDP and GNDI give similar results because there is no international or offshore trading.[13]

Note that we report to one decimal place only. This is because macroeconomic models such as our CGE model are not designed to forecast the outcomes of scenarios with spurious accuracy – they are suited to indicating the direction and broad magnitude of changes.

4.3. What might we expect to happen?

Prior to any modelling it is useful to discuss the kind of results that might be expected, given the limitations listed in section 1.4.

When non-forestry emitters face an increased price after the removal of a transition measure, we would expect the output of that industry to decline as their costs of business have increased, and for this to have an overall negative impact on the economy.

Because New Zealand will likely reach its 2020 target without additional emissions reductions, there will be no short term extra financial benefit from greater emissions reductions that accrue with industry facing a higher cost of emissions.[14]

Where there is no change in the market price (the price faced by the forestry sector), we would not expect to see a change in forestry emissions.

13 GNDI measures the total incomes New Zealand residents receive from both domestic production *and* net income flows from the rest of the world and adjusts for changes in the terms of trade. This is particularly relevant when considering policies to meet international obligations which may include a lump-sum offshore payment for excess emissions over a target. RGNDI includes these effects, whereas GDP just measures the amount of domestic production of goods and services, but does not capture international transfers and investment income. In this modelling exercise, there is no such international trading, so GNDI and GDP are very similar.

14 However, any long term investments made now may have additional benefits post-2020 in terms of reduced emissions and hence potential economic costs of reductions.

5. Macroeconomic results

5.1. Removal of the 1 for 2 surrender obligation

The removal of the 1 for 2 surrender obligation causes non-forestry emitters to face a higher effective emissions price. Real GDP is negatively impacted by an increase in the costs to industry, falling by 0.1% or $267 million under the medium emissions price assumption. Real wages fall, leading to a subsequent reduction in household consumption. The impacts increase as a function of the emissions price, as the effective subsidy provided by the 1 for 2 surrender obligation increases. Full details are available in Appendix B.

The reductions in household consumption lead directly to reductions in import volumes – an income effect. The decline in the exchange rate also puts further downward pressure on import demand. Conversely the lower exchange rate benefits exports by partially offsetting the decline in international competitiveness caused by the higher emissions prices. Thus imports react much more to higher emissions prices than exports.

Emissions are modestly reduced as industry and households face a higher emissions price. This causes a substitution away from emissions-intensive intermediate inputs and final products as prices become relatively higher for these items.

Table 6 Macroeconomic impacts of removing the 1 for 2 surrender obligation at the three carbon prices

Change from baseline where obligation remains in place at that emissions price, 2020

Metric	% change			Levels change ($m)		
Price scenario	**$10**	**$25**	**$50**	**Low**	**Medium**	**High**
Simulation comparison	1-4	2-5	3-6	1-4	2-5	3-6
Real GDP	-0.0	-0.1	-0.2	-106	-267	-539
Real GNDI	-0.0	-0.1	-0.2	-105	-264	-530
Consumer price index	-0.0	-0.1	-0.1	N/A	N/A	N/A
Average real wage	-0.2	-0.4	-0.8	N/A	N/A	N/A
Exchange rate	-0.0	-0.1	-0.2	N/A	N/A	N/A
Terms of trade	-0.0	-0.0	-0.0	N/A	N/A	N/A
Real consumption	-0.0	-0.1	-0.2	-61	-153	-307
Capital stock	-0.1	-0.2	-0.4	-88	-217	-425
Real investment	-0.1	-0.3	-0.7	-87	-216	-428
Import volumes	-0.1	-0.2	-0.4	-59	-145	-286
Export volumes	0.0	0.0	0.0	4	8	12
	% change in emissions			**Level of emissions change, kt CO2-e**		
Gross emissions	-0.3	-0.6	-1.1	-221	-546	-1,005
Net emissions	-0.3	-0.7	-1.5	-221	-546	-1,005

Source: NZIER

5.2. Removal of the $25/tonne fixed price option

Removal of the $25/tonne fixed price option has no material impact if the market emissions price is below $25. However if the market emissions price was to rise to an assumed $50/tonne after removal of this transition measure, there were would be associated negative effects.

Real GDP would fall by 0.1% or $267 million if the 1 for 2 surrender obligation was still in place; by 0.2% or $539 if the 1 for 2 surrender obligation has been removed.

The change in the market price (the price faced by forestry) causes sequestration to rise, and net emissions to fall.

The macroeconomic impacts of a smaller (larger) price after removal of the $25 fixed price option would be proportionally smaller (larger), and could be interpolated from the results presented here.

Table 7 Macroeconomic impacts of removing the $25/fixed price option if the price rises to $50/tonne

Change from 2020 baseline

Metric	% change		Levels change ($m)	
Price setting	**With 1 for 2**	**Without 1 for 2**	**With 1 for 2**	**Without 1 for 2**
Scenario comparison	2-3	5-6	2-3	5-6
Real GDP	-0.1	-0.2	-267	-539
Real GNDI	-0.1	-0.2	-264	-530
Consumer price index	-0.1	-0.1	N/A	N/A
Average real wage	-0.4	-0.8	N/A	N/A
Exchange rate	-0.1	-0.2	N/A	N/A
Terms of trade	0.0	0.0	N/A	N/A
Real consumption	-0.1	-0.2	-153	-307
Capital stock	-0.2	-0.4	-217	-425
Real investment	-0.3	-0.7	-216	-428
Import volumes	-0.2	-0.4	-145	-286
Export volumes	0.0	0.0	8	12
	% change in emissions		**Level of emissions change, kt CO2-e**	
Gross emissions	-0.6	-1.1	-546	-1,005
Net emissions	-11.0	-11.7	-8,277	-8,737

Source: NZIER

5.3. Household impacts by income quintile

The impact of removing the 1 for 2 surrender obligation measure across household quintiles is shown in Table 8.

The reductions in private consumption (i.e. household spending) are slightly larger among the lower (i.e. poorer) quintiles than the upper quintiles, reflecting both the assumed uniform proportionate reductions in household tax rates and the declining emissions intensity of consumption as income rises. That is, households in the higher income quintiles spend proportionately less on carbon-intensive goods and services (such as petrol and home heating) than those in lower income quintiles.[15]

Note however, that these are small differences in what are – at low prices at least – small changes in household consumption, so the levels impacts will be very small.

Table 8 Impact of removing the 1 for 2 transition measure on household spending by income quintile

% change from 2020 baseline, average per-household spending of $88,826

Price	Quintiles					Mean changes to household spending
	1 (lowest)	2	3	4	5 (highest)	
Low	-0.05	-0.05	-0.04	-0.04	-0.03	-0.04%
Medium	-0.13	-0.11	-0.10	-0.09	-0.08	-0.09%
High	-0.26	-0.25	-0.20	-0.18	-0.15	-0.19%

Source: Infometrics, based on NZIER model outputs

5.4. Regional and Māori impacts

While we have not explicitly modelled impacts on regions in New Zealand due to time constraints, the costs of removing the transitional measures will be relatively higher in regions which have a high proportion of economic activity in those sectors most affected.[16]

For example, regions with strong mining and oil and gas extraction industries, such as Taranaki (which also has a large dairy industry) and the West Coast, will also likely face higher adjustment costs. The Waikato region will also face relatively higher adjustment costs due to the proportionately larger share of its economy based on non-renewable energy and agriculture. And we would expect regions with a high concentration of dairy cattle, beef and sheep farming such as Canterbury to suffer relatively more.

Our model database does not split out Māori businesses and workers, but we know that the non-forestry Māori economy is relatively heavily concentrated in the primary sector, which is relatively strongly negatively affected by the removal of transitional measures.

15 Emissions from international air travel are not counted as part of New Zealand's emissions.

16 We would caution against taking these examples as gospel. More detailed regional modelling that fully takes into account regional economic structures and offsetting effects (e.g. the boost to many services sectors) would be required to validate these high-level inferences.

However, these negative impacts will be at least partially offset by boosts to Māori enterprises in the renewable energy sector and the tourism sector. The impacts on Māori forestry holdings is difficult to estimate, as much will depend on whether ownership is of pre-1990 forests or post-1989 forests.

More detailed analysis, including additional forestry sector modelling, is required to estimate the net impacts, which will also vary by region due to differences in the composition of the Māori economy around New Zealand.

5.5. Forestry discussion

Our CGE model does not determine forest sequestrations projections, and these are defined externally to the model based on scenarios from MPI. Due to the 2020 focus year, our modelling only captures the economic cost on forestry of higher energy costs and other relative price changes to intermediates and factor inputs.

The CGE model is not designed to pick up the economic impact of changes in the timing of harvesting that may result from fluctuations in the value of carbon credits. As the CGE model is static, it is also not designed to pick up the positive economic impact that increases in emissions prices may have on afforestation and therefore eventual harvesting.

Higher effective emissions prices will have three impacts:

- Delayed harvest of those forests that are rewarded for sequestration within the ETS and face a liability for harvest
- Reduced deforestation rates (as forests are replanted, rather than cleared for alternative land uses)
- Increased afforestation (expected to have a minor effect on sequestration in 2020 but a greater impact post-2020).

Harvest considerations

When faced with higher emissions prices, it becomes economic for the post-1989 forests that are in the ETS to delay harvest until after the year of these modelled scenarios (2020). This creates the appearance of a significant decline in harvesting of forests, and therefore forest sector income.

However, in such a scenario, the harvest of forests *outside* the ETS is expected to be brought forward and increased to compensate, meeting demand for timber. This will change the mix of forests being harvested (pre-1990 vs. post-1989) in 2020 and beyond, meaning any reduction in harvest will likely be less than that shown in the post-1989 data.

In the longer run, the increased afforestation that is driven by higher returns from carbon credits within the ETS will allow greater volumes of harvest in the future.

Given the above points, the economic costs on the forestry sector (i.e. those growing and harvesting trees) within this report are likely to be overstated, and we recommend additional forestry-specific modelling be carried out to explore these issues in more depth. The wood processing industry results reported here, however, do capture the negative impact of higher energy prices on processing volumes.

5.6. Impacts of changes in international climate change settings

If by 2020 our key trading partners all adopted new climate change policies that imposed higher emissions prices, or if the world adopted a global agreement with full international trading of emissions permits, both our reference case and the scenarios after the removal of the transition measures would be affected by similar amounts. That is, there would be a level shift, but the change in impacts from the baseline would not be materially affected.

There would therefore be a minimal *net* effect on the relative costs of removing the transition measures.

However if the removal of a transition measure in New Zealand is associated with, or is a reaction to, our international partners imposing more stringent climate change policies, the relative costs of removing the transition measures would fall. Our previous modelling (NZIER and Infometrics 2009) found that equivalent rest-of-the-world action can approximately halve domestic costs relative to unilateral action.

6. Industry impacts

6.1. Removal of the 1 for 2 surrender obligation

The industry impacts from the removal of the 1 for 2 surrender obligation are shown in the table below for selected industries.

Table 9 Industry impacts from removing the 1 for 2 surrender obligation

Change from 2020 baseline, industry value added (GDP), selected industries

Metric	% change			Levels change ($m)		
Price setting	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Horticulture	-0.1	-0.2	-0.4	-0.9	-2.5	-5.4
Sheep, beef farming	-0.1	-0.2	-0.3	-2.9	-7.5	-16.2
Dairy cattle farming	-0.1	-0.2	-0.3	-3.2	-8.5	-18.3
Coal mining	-0.3	-0.8	-1.6	-2.1	-5.3	-10.9
Non-metallic mineral mining	-0.2	-0.6	-1.2	-2.5	-6.3	-12.9
Meat manufacturing	-0.1	-0.2	-0.4	-2.9	-7.6	-16.2
Dairy product manufacturing	-0.1	-0.2	-0.4	-6.0	-15.7	-33.7
Textile and leather manufacturing	0.0	0.0	-0.1	-0.1	-0.2	-0.7
Wood product manufacturing	-0.1	-0.2	-0.4	-1.2	-3.2	-7.0
Fertiliser manufacturing	-0.2	-0.5	-1.0	-0.8	-2.2	-4.9
Primary metal manufacturing	-0.1	-0.2	-0.3	-0.9	-2.3	-4.4
Non-renewable electricity generation	-2.8	-6.4	-11.0	-19.8	-46.1	-81.8
Renewable electricity generation	0.1	0.2	0.2	3.3	7.1	10.7
Waste collection, treatment	-0.2	-0.4	-0.9	-2.8	-6.7	-12.5
Residential building construction	-0.1	-0.3	-0.6	-4.2	-10.7	-22.0
Supermarket and grocery stores	-0.1	-0.3	-0.6	-1.9	-4.8	-9.9
Recreation retailing	-0.1	-0.1	-0.3	-0.6	-1.4	-3.0
Accommodation	0.2	0.5	1.1	3.2	8.3	16.9

Source: NZIER

The agricultural industries are negatively affected, driven in large part by the negative impact on energy-intensive food processing. As food processors start to face higher costs after the removal of the 1 for 2 obligation, they will seek to reduce production. This will reduce the demand for raw product from the on-farm sector, as well as in associated agri-services industries.

Production in the mining industries is negatively impacted by as much as 1.6% under the high price setting, as energy costs rise and the cost of processing their raw materials also rises.

Manufacturing industry impacts are a mixed bag: those related to metals, minerals or energy generation decline, while others benefit from the reduction in the exchange rate.

In energy, there is a switch from non-renewables to renewables as the relative prices tilt in favour of the renewables.

Retail industries decline due to the reduction in real wages, while tourism industries such as accommodation benefit from a lowering of the exchange rate.

The largest emissions reductions come from the move towards renewable electricity generation, and reductions in road transport, waste and agricultural production.[17]

Table 10 Industry emissions impacts from removing the 1 for 2 surrender obligation

Change from 2020 baseline, industry emissions, selected industries

Metric	% change			Levels change (kt CO2-e)		
Price setting	**Low**	**Medium**	**High**	**Low**	**Medium**	**High**
Non-renewable electricity generation	-3.6	-8.2	-14.2	-103.5	-236.3	-407.8
Road transport	-0.4	-1.0	-1.9	-54.3	-129.0	-238.7
Dairy cattle farming	-0.1	-0.2	-0.3	-16.1	-41.4	-86.0
Waste collection, treatment	-0.4	-1.0	-1.8	-19.7	-45.9	-82.5
Electrical equipment manufacturing	-0.8	-1.9	-3.8	-16.0	-39.2	-76.2
Sheep, beef farming	-0.1	-0.2	-0.3	-13.2	-33.8	-70.2
Petroleum and coal product manufacturing	-0.3	-0.7	-1.4	-2.6	-6.3	-12.3
Non-metallic mineral mining	-0.2	-0.6	-1.2	-2.1	-5.3	-10.5
Exploration and other mining support services	-0.3	-0.7	-1.4	-2.0	-4.9	-9.5
Coal mining	-0.3	-0.8	-1.7	-1.4	-3.4	-6.8

Source: NZIER

[17] The falls in agricultural emissions are mainly caused by a decrease in head count.

6.2. Removal of the $25/tonne fixed price option

Recall that if the $25/tonne fixed price option is not a binding cap (i.e. if the market emissions price is lower than $25), then there is little material impact from its removal. However if the cap is binding, removing it would increase the market price faced by industry. The impact of removing the transition measure would then depend on the extent of the price rise.

If the 1 for 2 surrender obligation is in place, a $25/tonne price rise would equate to an effective price rise for non-forestry emitters of $12.50. The industry impacts of such a change are equivalent to those shown in the medium price setting results in the analysis of the 1 for 2 surrender obligation (Table 9 and Table 10 above).

If the 1 for 2 surrender obligation was also removed, a $25/tonne price rise would equate to a $25/tonne price rise for non-forestry emitters. The industry impacts of such a change are equivalent to those shown in the high price setting results in the analysis of the 1 for 2 surrender obligation (Table 9 and Table 10 above).

7. Conclusion

Notwithstanding the limitations to our analysis listed in Section 1, in our view the overall conclusions remain robust: the removal of the 1 for 2 surrender obligation measure will have only modest macroeconomic and industry-level impacts, particularly if 2020 emissions prices fall closer to $25/tonne than $50/tonne.

This is largely due to free allocation protecting energy-intensive trade-exposed industries from competitiveness-at-risk issues.

The removal of the $25/tonne fixed price option is unlikely to have a material impact unless the market emissions price rises well beyond $25/tonne.

Appendix A Free allocation

Table 11 Free Allocation levels and concordance with CGE industry

Activity	Free allocation level	NZU units in 2014	CGE industry concordance
Iron and steel from iron sand	90%	1,073,489	28 PrimMetMan
Methanol	90%	777,432	23 BChemMan
Aluminium smelting	90%	755,987	28 PrimMetMan
Cementitious products	90%	505,693	27 NMMMan
Market pulp	90%	356,862	20 PulpPapMan
Carbamide	90%	198,469	24 FertMan
Packaging and industrial paper	90%	144,261	20 PulpPapMan
Burnt lime	90%	142,567	27 NMMMan
Newsprint	90%	124,989	20 PulpPapMan
Cartonboard	90%	79,866	20 PulpPapMan
Carbon steel from cold ferrous feed	90%	59,830	28 PrimMetMan
Protein meal	60%	56,830	12 MeatManuf
Reconstituted wood panels	60%	39,260	19 WoodMan
Glass containers	60%	35,515	27 NMMMan
Lactose	60%	26,109	14 DairyProduc
Fresh tomatoes	60%	24,704	1 Horticulture
Tissue paper	60%	18,064	20 PulpPapMan
Fresh capsicums	60%	15,552	1 Horticulture
Hydrogen peroxide	90%	11,212	23 BChemMan
Caustic soda	90%	9,474	20 PulpPapMan
Fresh cucumbers	60%	8,085	1 Horticulture
Ethanol	60%	6,191	14 DairyProduc
Cut roses	90%	3,153	1 Horticulture
Gelatine	60%	2,917	14 DairyProduc
Clay bricks and field tiles	60%	2,418	27 NMMMan
Whey powder	60%	830	14 DairyProduc

Source: NZIER, https://www.climatechange.govt.nz/emissions-trading-scheme/participating/industry/allocation/decisions/

Appendix B Individual scenario results

The results from the individual scenarios (described in Table 3) are presented below. Scenario 2 is the base case reference. All results are relative to this base case.

Table 12 Macroeconomic impacts by scenarios

% change from 2020 baseline scenario 2

Metric	Scenarios					
Scenario	**1**	**2**	**3**	**4**	**5**	**6**
Real GDP	0.1	0.0	-0.1	0.0	-0.1	-0.3
Real GNDI	0.1	0.0	-0.1	0.0	-0.1	-0.3
Consumer price index	0.0	0.0	-0.1	0.0	-0.1	-0.1
Average real wage	0.2	0.0	-0.4	0.1	-0.4	-1.2
Exchange rate	0.1	0.0	-0.1	0.0	-0.1	-0.3
Terms of trade	0.0	0.0	0.0	0.0	0.0	0.0
Real consumption	0.1	0.0	-0.1	0.0	-0.1	-0.3
Capital stock	0.1	0.0	-0.2	0.0	-0.2	-0.5
Real investment	0.2	0.0	-0.3	0.1	-0.3	-1.0
Import volumes	0.1	0.0	-0.2	0.0	-0.2	-0.6
Export volumes	0.0	0.0	0.0	0.0	0.0	0.0
Gross emissions	0.4	0.0	-0.6	0.1	-0.6	-1.7
Net emissions	11.8	0.0	-11.0	11.5	-0.7	-12.4

Source: NZIER

Appendix C Discussion of CGE modelling

This section is reproduced from NZIER and Infometrics. (2009). 'Economic modelling of New Zealand climate change policy'.

https://www.climatechange.govt.nz/emissions-trading-scheme/building/reports/economic-modelling/economic-modelling-of-new-zealand-climate-change-policy.pdf

C.1 What is CGE modelling?

Computable General Equilibrium (CGE) models are commonly used tools for policy analysis. Such models typically consist of a database that represents an economy benchmarked for a particular time period based on input-output tables. The database specifies the interactions and relationships between various economic agents including firms, workers, households, the government and overseas markets.

The base case model is then 'shocked' by changing a policy variable or an assumption about one or more parameters outside the model (so-called exogenous variables). Values for all other variables inside the model (so-called endogenous variables) are calculated from equations describing the economy, given numerical values for the parameters and the variables outside the model (Peterson, 2003).

The equations describing the relationships between economic agents exhibit a number of common features based on neoclassical economics (Peterson, 2003):

- Consumers maximise their utility subject to their budget constraints. They purchase goods and services from firms, and provide firms with their labour inputs.
- Producers 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 (goods and intermediates) and in equilibrium market prices are such that demand equals supply in all input and output markets.
- Under the standard assumption of constant returns to scale firms earn zero pure profit (i.e. enough to remain in business but not enough to induce new firms to enter the market).

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, etc. In static CGE models, we observe the economy after all adjustments have taken place. Dynamic models, on the other hand, allow us to examine in each intervening period how variables adjust from the time when a shock is implemented to the time when all of its effects have worked through the economy (which may be a number of years).

C.2 Strengths of CGE modelling

The most important advantage of CGE modelling is that it considers how policy shocks affect the allocation of resources between all sectors and markets in an economy. This is essential if we are to get a good macroeconomic understanding of how policy changes might affect the structure of an economy. Concept Economics (2008, p4) note that "high quality CGE modelling is a powerful tool that can assist policy makers and stakeholders in understanding the effects of mitigation actions, especially at an economy wide level".

In addition, such models "examine complex issues rigorously and in an internally consistent way across long timeframes" (Australian Treasury, 2008, p21). CGE models have been used extensively for climate change policy because they can examine adjustments across all sectors of the economy to changes in energy supply and prices through changes in factor proportions and sectoral output levels.

Sector-specific partial equilibrium or econometric models, on the other hand, tend not to consider what happens to resources outside of the sector in question. While they can be useful for more disaggregated sectoral analysis, they are not well-suited for capturing the inter-sectoral resource re-allocation that stems from policy changes such as the ETS.

C.3 Limitations of CGE modelling – generic

One important aspect of CGE modelling is 'database dependency' (NZIER, 2008). By this we mean that the accuracy of CGE modelling results is highly dependent on the quality and suitability of the initial database employed in the base case scenario. To the extent that there are problems with the database, there may also be problems with the results.

In the modelling of New Zealand's ETS by NZIER and Infometrics, the base case model structure is based on the snapshot of the economy provided by Statistics NZ in their latest 2003 Supply and Use Tables, in turn an update on previous more comprehensive input-output tables from 1995/96. Structural changes to the economy over the last 5 years are therefore not captured in the model database, but are in the Business as Usual scenario.

An oft-used criticism of CGE models, at least historically, is that, given the vast amount of data, parameters, equations and assumptions required to compute outcomes, such models can be somewhat of a "black box" in nature. That is, it is sometimes difficult to identify exactly how certain results were obtained.

This is true only to the extent that modellers are not transparent regarding what data they have put into the model, how they have modelled policy changes and how they have interpreted the results. As shown below, more often than not, differences in results between different models can be explained relatively simply by working systematically through the key data, parameters and assumptions employed.

As such, any allegations of a lack of transparency should usually be levelled at the individual CGE modeller, rather than the CGE model itself.

A more valid criticism is that CGE model estimates are not often 'tested' ex-post against actual outcomes. This makes it difficult to ascertain how 'accurate' CGE modelling results are in practice (Kehoe, 2003). Such ex-post testing is rare because retrospectively isolating the specific effects of any individual policy changes from other economic changes is very difficult. In static CGE modelling, we generally have to assume that apart from policy shocks, everything else remains constant (or at least behaves in the way that we have told the model to react). In reality of course economies adjust constantly in response to good or bad news, relative price changes, availability of resources, exchange rate movements, shifts in preferences, changes to global markets, other policy changes and so on.

Partly as a result of not knowing whether or not previous studies have been accurate, there is relatively little focus on ensuring that the parameters contained within a model remain appropriate. Econometrically estimating these parameters is a complex and expensive process, but it is widely accepted that "in order for CGE models to gain prominence in policy analysis, more must be done to ensure the model is an accurate representation of the real economy" (Beckman and Hertel, 2009, p.7).

As noted above, CGE models typically assume a neoclassical world. If these neoclassical assumptions are not believed to hold true in reality, then the model results could be seen as not portraying likely outcomes. However, alternative representations of economic behaviour can be incorporated into CGE models if judged to be more appropriate.

Another limitation of static CGE models, such as those employed in this report, is that they usually assume that economic variables adjust smoothly to policy shocks. Such models do not capture step-wise industry adjustments but assume smooth and continuous changes. In reality, industries with large capital resources face discrete production and investment decisions.

Along similar lines, comparative static models report the likely change in the economy at a given point in time; they do not capture the gradual implementation effects of a shock as the economy adjusts over time. This is more of a concern for short run modelling scenarios. In the long run, it is assumed that the economy can adjust to the desired point, although different models use different approaches to the movement of labour and capital to allow this adjustment (also see Australian Treasury, 2008, p22, who note that the three CGE models used in their analysis "provide a more robust analysis of the post-transition economy than of the transitional process [itself]").

C.4 Limitations of CGE modelling of climate change policy

The application of CGE modelling to climate change mitigation policy scenarios is now widespread (Beckman and Hertel, 2009, p1). This is because CGE models are well suited to examining the inter-sectoral and inter-country effects of pricing carbon dioxide and other greenhouse gases.

However, a number of common challenges face modellers of climate change policies (Australian Treasury, 2008; Sohngen, Golub and Hertel, 2008). These include:

- Accurately accounting for land use changes – although CGE models to assess climate change policies are becoming more sophisticated, they are not yet able to fully capture the opportunity costs of alternative land-uses and land-based mitigation strategies. This is largely due to a lack of high quality economy wide data, specifically, consistent global land resource and non-CO2 GHG emissions databases linked to underlying economic activity and GHG emissions and sequestration drivers (Australian Treasury, 2008).

- The modelling of forestry land use, particularly in static CGE models, is especially problematic, due to long investment timeframes and difficulties capturing the intertemporal aspects of forest carbon management (Sohngen, Golub and Hertel, 2008, p4).
- Estimating abatement costs – the costs to individual sectors (and hence the macroeconomic costs and benefits) of mitigating climate change vary depending on the ability of firms to reduce emissions in an economically efficient way. The ability of firms to adjust is largely dependent on the possibility of substituting towards less emissions-intensive production processes or materials and the development of cost-reducing technological advances. These effects are uncertain and require the use of assumptions.
- In general, endogenous technological improvements are not modelled, but we examine some scenarios with technological change induced by a carbon price. If forestry is more responsive to a carbon price than our models assume, our scenarios will overstate the level of costs of a broad ETS that covers the forestry sector, both relative to BAU and relative to a narrow based tax that does not cover forestry. More detailed land use change modelling would help policy makers better identify the costs and benefits of meeting our international obligations.
- Another source of potential bias relates to the fact that CGE models do not incorporate full marginal income tax schedules. As a result the models will underestimate the welfare gains from lower taxation to households.
- Non-economic costs and benefits are generally not captured in CGE models. For example, CGE models do not generally capture changes to social and health outcomes that may arise from climate change mitigation policies, even though these outcomes may have real economic costs and benefits.