Economic modelling of New Zealand climate change policy

Report to Ministry for the Environment

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Preface

This report has been prepared jointly by NZIER and Infometrics.

NZIER is an independent specialist consulting firm, established in 1958, that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield. NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions. It prides itself on its reputation for independence and delivering quality analysis in the right form, and at the right time, for its clients.

Infometrics Ltd is a privately owned and operated company. It offers a range of economic consulting and forecasting services on commercial terms to companies, business organisations and government departments. Since being founded in 1983 the company has built a reputation for rigorous and independent work, delivered on time and within budget.

Authorship

This report has been prepared by Adolf Stroombergen (Infometrics) and Chris Schilling and John Ballingall (NZIER) and reviewed by Jean-Pierre de Raad (NZIER). We gratefully acknowledge, without implication, the comments from Tim Denne of Covec.

Executive summary

Objectives of report

This report examines the macroeconomic effects of policy options for climate change mitigation in New Zealand. We examine the short run (to 2012) and long run (to 2025) impacts of a number of possible scenarios. These scenarios include an Emissions Trading Scheme (ETS) as previously proposed and various carbon tax alternatives. We consider the effects on economic welfare measures of issues such as different domestic carbon price levels, whether the rest of the world prices carbon; the free allocation of emissions permits to certain trade-exposed, emissions-intensive sectors; and technological change.

Modelling approach

We use static computable general equilibrium (CGE) modelling to assess the economic effects of climate change mitigation policies. CGE models are generally accepted as being an appropriate tool for such analysis as they track the reactions of firms, households and government to changes in policy settings by considering how resources are reallocated between sectors and factor markets.

Due to the theoretical equivalence of cap and trade systems and carbon taxes in achieving a given level of emissions reduction, we model an ETS as a carbon tax. In practice, there are differences such as the impact of price and quantity certainty, complexity, measurement and administration costs, and ease of linkages to the international market, although we cannot accurately capture such differences in our CGE modelling framework.

We have modelled a number of scenarios. This is necessary due to the inherent uncertainty around many of the central drivers of the domestic economic impacts of climate change mitigation policies such as:

- the world carbon price[1]
- abatement technology opportunities
- the role of land use changes and forestry
- the approach taken by New Zealand's trading partners.

Until there is greater certainty around these issues, our estimates of the economic effects are indicative only, particularly as the time horizon lengthens. The modelling estimates should be interpreted not as point estimates or precise forecasts. Rather they are indicative of the direction and relative magnitude of the changes in some key measures of economic welfare as a result of certain policy scenarios under certain assumptions.

1 We use 'carbon price' as short hand for the pricing of all greenhouse gas emissions.

The specification of the various model runs were discussed and agreed with the Ministry for the Environment but the detailed assumptions around the modelling are our responsibility.

Previous New Zealand modelling of an ETS

Previous CGE modelling by Infometrics and NZIER (both 2008) of the macroeconomic effects of the previously proposed ETS showed quite different outcomes, and in particular Infometrics' modelling showed lower macroeconomic impacts than NZIER's modelling. This report reconciles the main differences between these earlier modelling exercises and finds that, once the key assumptions that underpin the two models are controlled for, the two models produce very similar results.

The most critical assumption relates to the treatment of capital movement in the long run (both models assume that labour is fixed in the long run). When the capital stock is held fixed in the long run, as in Infometrics' earlier work, the macroeconomic effects of an ETS are necessarily constrained as the economy cannot contract due to reductions in factor accumulation (i.e. two of the key drivers of economic activity levels, the size of the capital stock and labour force, cannot change).

The modelling in this report was carried out by NZIER and Infometrics separately, although both consultants worked closely together. The two models are structurally similar, however some important differences remain. The sources of difference include the models' respective behavioural parameters, database construction, aggregation schemes and views on factor mobility. Differences in results of a few points of a percent should not be interpreted as contradictory, but rather as indicating margins of error. It is not possible to determine which model is 'better' as this would involve making subjective and largely arbitrary choices over model inputs and structures in terms of their validity during the first Commitment Period and beyond. We present both models' results, and focus on their interpretation and common conclusions. A similar approach was taken in Australian modelling exercises undertaken by the Australian Treasury (2008).

We have not examined the sector-specific or regional economic impacts of climate change mitigation policies in this report, as our emphasis is on the economy wide costs and benefits. Regional and sectoral effects will differ considerably from the economy wide results presented in this paper – some will experience much larger economic costs and others will benefit. A discussion of such impacts can be found in NZIER (2008) and Infometrics (2008).

Conceptual framework

We start from the premise that New Zealand continues to be part of future international climate change agreements. **New Zealand signing up to Kyoto and any subsequent international agreement results in a net welfare loss, no matter**

which instrument is used to account for our liability.[2] We have been asked to determine the least cost approach to meeting these obligations – that is, to identify the instrument(s) that minimize this welfare loss.

There are a number of policy options available to New Zealand to pay for any international liability. The options are all on a continuum between the following two ‘extreme’ bounds:

(i) The government purchases all of the liability offshore using general taxation to raise the revenue required to do so. In this scenario, no carbon price is introduced in the New Zealand economy.

(ii) The government introduces a price for all greenhouse gases in all sectors, with no exclusions. In this scenario, emitters face the entire burden of the international liability.

Between these bounds, there are a variety of approaches to meeting our liability. These approaches include:

- A narrow carbon tax or ETS that applies to selected sectors such as energy and transport.
- A carbon tax or ETS with a domestic price that is lower than the world price.
- A carbon tax or ETS with free allocation of emissions permits to major emitting industries.

Any combination of the above is also possible. The approach used determines the relative burden faced by the government and emitters in order to meet our international liability. For example, relative to (ii) above, the free allocation of permits shifts some of the burden away from emitters and towards government.

Each time the burden shifts, the size and distribution of the costs and benefits do as well. The benefit of a price on carbon, relative to government simply paying the bill, is that it provides an incentive for emissions abatement. Every tonne of emissions abated reduces New Zealand’s international liability (i.e. benefits New Zealand). However there is a cost to the economy of abating emissions. This cost is dependent on:

- the ease with which firms can substitute away from emission-intensive activities
- action by the rest of the world to price carbon
- the availability and cost of abatement technology.

[2] This work was based on 2008 MfE emissions projections which showed a New Zealand Kyoto deficit. Data released since our modelling was completed shows that New Zealand has a Kyoto surplus, due largely to the effects of the 2008 drought on agriculture. Our key results about the relative properties and desirability of different abatement policies remain valid despite the change in New Zealand’s net position, However, the overall level effects of any abatement policy may vary significantly depending on our liability or surplus.

Our modelling identifies the balance between these benefits and costs under a number of scenarios, both in the short and long run.

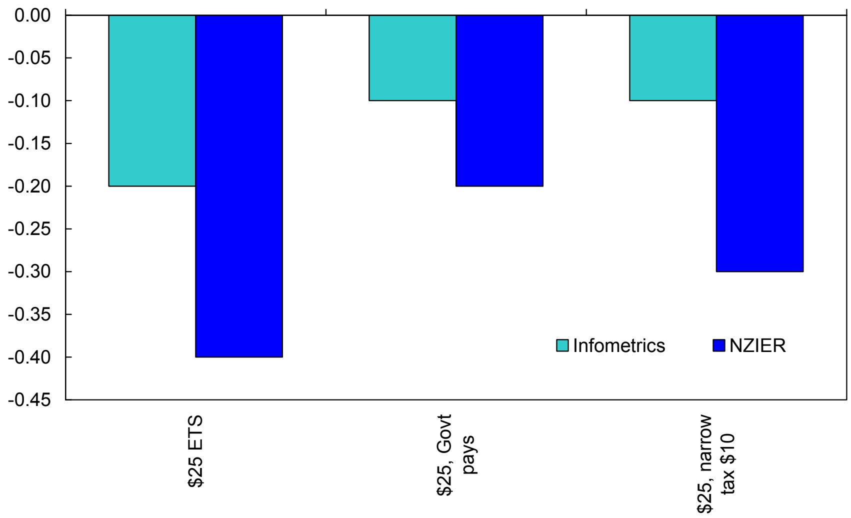
Response to Terms of Reference

As shown in Figure 1, our modelling shows that in the short term, which is characterised by less price flexibility in factor markets, a low carbon price, and no major technological advances, the least cost way of meeting our international liability is through government purchasing permits funded by an increase in general taxation (if benefits of avoiding deforestation are not especially significant).[3] This approach, however, does not introduce a price signal into the economy. As a result, firms face little incentive to change their production techniques or to invest in emissions-reducing technology.

If a price is to be introduced into the New Zealand economy, a narrow carbon pricing scheme – whether tax or cap and trade – is marginally less costly than a broad based tax or trading scheme with free allocation (the ETS) in the short run.

Figure 1 Short run modelling results

% change in real GNDI



Source: NZIER and Infometrics

However, note the scale on the chart: **there is little difference** – at an economy wide level – between the welfare effects of the government paying, a narrow tax/trading scheme tax and the ETS with free allocation as proposed (putting aside transaction costs differences) when the world price is low.

On the assumption that a carbon price will be desired in the longer term to be more consistent with the actions of other countries, the government pays scenario is unlikely to be a realistic policy option, unless the government's carbon permit purchasing options are significantly less expensive than that of the private sector.

[3] Note that potential benefits from avoiding deforestation can be captured under either a tax or an ETS. If these are significant, then this may tip the balance towards some action in the short term.

Accordingly the least cost option for meeting New Zealand's obligation during the first Commitment Period, consistent with optimal long term policy, is a narrow carbon tax or narrow trading scheme.[4]

The 2012 welfare impact of a narrow pricing scheme with a low domestic price is in the range -0.1% to -0.3% of Gross National Disposable Income (GNDI). The welfare impacts of the ETS as previously proposed range from -0.2% of GNDI at low prices of carbon rising to -0.8% at higher prices of carbon, when compared to a Business as Usual (BAU) scenario where there is no New Zealand commitment to an international agreement.[5] The BAU is in fact a rather artificial scenario if viewed from the perspective that New Zealand has signed up to Kyoto and therefore must meet its obligations. New Zealand does not have the BAU option of ignoring Kyoto. Thus the costs we report are the costs of having signed up to Kyoto and the government paying or using an ETS or a tax to meet these obligations.

In the longer term to 2025, we must consider more explicitly the actions of the rest of the world and the degree of technological improvements available to New Zealand firms.[6] These have important impacts on the economy wide cost of abatement. Our modelling shows that **if the rest of the world takes steps to price carbon, and technological change is induced by this pricing, then a broad-based domestic carbon pricing scheme is the least cost way to meet New Zealand's international obligations**. Without action by the rest of the world or technological change, the least cost option can include the free allocation of permits and exemptions for some industries and/or gases.

As the carbon price rises past a certain level, the models show that some form of pricing scheme becomes lower cost than the government pays, even when no action is assumed by the rest of the world and there is no technological change. The point at which a carbon price becomes preferable differs between the two models. At $25/tonne, Infometrics' model ranks a carbon price equal to a government pays scenario while the NZIER model slightly favours the latter. At higher prices, both models show that introducing a carbon price is preferable to a government pays scenario.

The key long run modelling results are as follows:

1. **The actions of the rest of the world are important**: If New Zealand takes unilateral action on comprehensively pricing carbon and the rest of the world

[4] Potentially including measures to avoid deforestation risks.

[5] When interpreting these results, it is important to note that a negative value means that the measure (GNDI, employment, etc) is lower than it would have been otherwise in the absence of any climate change mitigation policy. This is not the same as saying that welfare will be lower than it is now. In all scenarios we still expect the level of welfare or economic activity to increase, but at a slower rate than projected in the business as usual (BAU) scenario.

[6] In our modelling framework, the actions of the rest of the world are modelled as binary choices – they either occur or the don't, but in reality will occur along a continuum between no action and full action. Similarly, technology improvements are modelled by some discrete examples, but in reality technology is a function of price and time – improvements are more likely to be available in the longer run than in the short run.

does not, New Zealand's national economic welfare (RGNDI) is around 0.3% to 0.6% lower than under a scenario where the world does price carbon on all commodities.[7] In reality we can expect an outcome between these two extremes. The impacts on New Zealand reflect its unique, export-centric emissions profile, and highlights why New Zealand should continue to push for global agreements on carbon pricing as a policy priority.

2. **Free allocation can reduce welfare losses particularly when there is only limited action by the rest of the world and there are few abatement technology options available to industry**: Until there is clearer evidence about the actions of the rest of the world and the nature of technological improvements, our modelling shows that there is value in designing any pricing scheme with some flexibility to prevent significant leakage or damage to key industries. Note that free allocation does not mean that there is no incentive to reduce emissions. There is still an opportunity cost of holding the permit; if actions to reduce emissions are less costly than the value of the permit, then reducing emissions makes good economic sense.

   Our modelling suggests that New Zealand will continue to meet any future international obligation primarily by purchasing international emission units rather than by domestic emissions reductions. This occurs because domestic abatement opportunities are limited and costly, and are often associated with output contractions. These contractions can have negative flow-on effects across the rest of the economy. As a result, in a general equilibrium framework, it can be more expensive (economy wide) to abate domestically than to purchase emissions units offshore. That is, the negative effects of less foreign exchange earned by export industries would outweigh the positive effects of more domestic abatement induced by carbon charge. In such situations, a pure price instrument may not be the least cost method of meeting New Zealand's international obligation unless accompanied by the free allocation of emission rights to internationally exposed industries (as a production subsidy to account for a loss of international competitiveness). Over time, we would expect the case for free allocation to diminish as other countries take action and technology improvements become available.

3. **Free allocation for stranded assets is more costly than production-linked free allocation**: If free allocation is based on a lump sum payment to compensate firms for stranded assets, the welfare loss is greater than under a production subsidy approach. This is primarily because these lump sum subsidies are not used to offset the price of carbon, but are instead returned to business owners, many of whom reside overseas. This reduces our preferred measure of national economic welfare (RGNDI), underlining the need to be clear about what free allocation is intended to address – compensation for lower asset

[7] This provides some scale around the costs of the loss of competitiveness that entering a Kyoto style agreement imposes on the New Zealand economy.

values, exposure to international competition (and carbon leakage), or some concept of minimum regret.

4. **The higher the world carbon price, the greater the cost to the New Zealand economy**: An increase in the price of carbon from $25 to $100 (per tonne of CO_2) raises the welfare cost from around 1.0% of RGNDI to 3.0% to 3.5%.

5. **The New Zealand economy will continue to grow under a carbon pricing scheme**, albeit at a slightly lower rate. In the absence of any policy change, we estimate RGNDI will grow from around $38,500 per capita in 2009 to $56,000 per capita in 2025. Under a carbon pricing scheme with a world price of $100, this will fall by between $1,700 and $2,000 by 2025.

6. **New abatement technologies improve the relative welfare impact of price instruments**. Such technologies result in higher levels of emissions abatement at lower costs to the economy. When the abatement cost is below the world price of carbon, a pricing scheme is the least cost option for meeting our obligation. In approximate terms, every 2% fall in total emissions from new abatement technologies reduces the loss in economic welfare by around 0.1%.

   The development of abatement technologies can be positively influenced by a price on carbon.[8] We do not capture this explicitly within our models. However while a price on carbon increases the pay-off to abatement technology, it does not guarantee 'silver bullet' solutions.

7. **Changes in the size of the capital stock have significant economic effects**: The modelling assumption regarding whether the capital stock is able to vary in the long run has a significant effect on the results. If the total capital stock in the economy is invariant to the introduction of a carbon price, the welfare losses are lower: At a carbon price of $25, the welfare loss is reduced by 0.5%. At $100 the effect is around 2.0%.

8. **Differential pricing has minimal impacts**: Under a narrow tax our models show no measurable welfare impact from the carbon price in New Zealand being either $10 or $40 when the world price is $25. This reflects the fact that at low prices of carbon New Zealand meets the vast majority of its obligations by purchasing offshore. If the world price is higher, differential pricing may have more significant negative welfare impacts.

9. In rough terms the size of our Kyoto obligation means that in 2012 New Zealand has to buy emission permits to cover about 9 Mt of CO_2. At $25/tonne this implies $225 million of payments offshore every year of CP1, or $1,125 million over the five years of CP1. We can think of this as the size of the 'shock' to the economy. To put this into some sort of perspective, the reduction of import tariffs from their

8 It is more likely that abatement technologies are developed over a longer rather than a shorter time-frame.

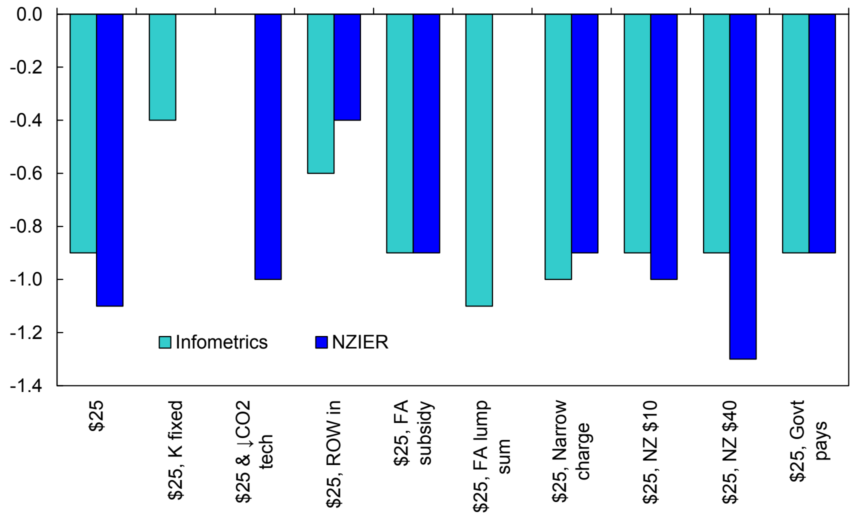
1986 level would, if it took place over CP1, imply an economic shock of about $4,400 million in current prices.

The changes in RGNDI for the long term scenarios are illustrated in the two graphs below. The first relates to a carbon price of $25/tonne. It shows the importance of action by the rest of the world in lowering the cost to New Zealand of meeting any international emissions obligation. The graph also shows the relative closeness of the two sets of results for most scenarios.

The second graph clearly demonstrates the effect of a higher carbon price and the potential contribution from new abatement technologies that might be encouraged by a high carbon price.

Figure 2 Long run modelling results: $25 price

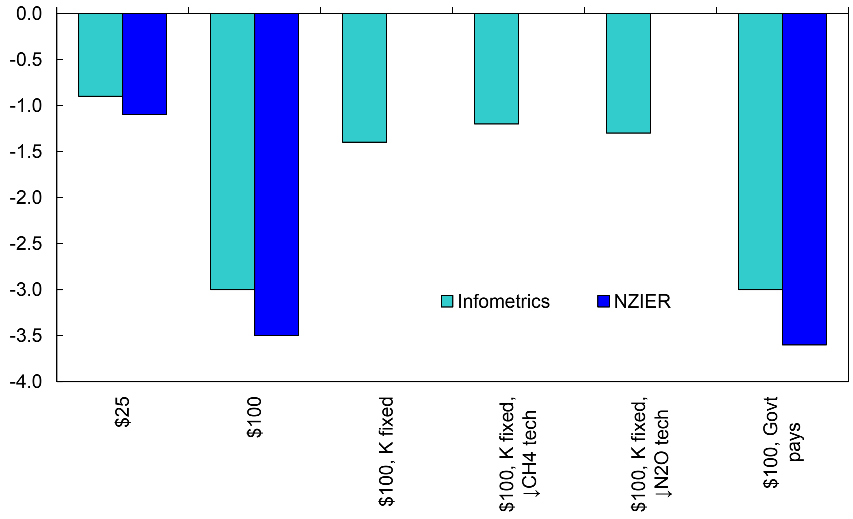
% change in real GNDI



Source: NZIER and Infometrics

Figure 3 Long run modelling results: $100 price

% change in real GNDI



Source: NZIER and Infometrics

Conclusions and recommendations

1. The New Zealand economy will continue to grow under all of the scenarios that we have modelled. In the absence of any policy change, we estimate that income per capita (as measured by RGNDI) will grow from around $38,500 in 2009 to $56,000 in 2025. The introduction of a carbon price will not significantly affect New Zealand's potential *growth* rate.

2. However, there is a cost to meeting our international commitments. Under a carbon pricing scheme with a world price of $100, per capita income could fall by up to $2,000 by 2025. The magnitude of the economy wide costs of meeting our international obligations are not determined solely by domestic policy settings. The actions of the rest of the world and the level of the world carbon price have important ramifications for the cost to the New Zealand economy.

3. In the short run, there is relatively little difference, at the macroeconomic level, between the government funding our Kyoto liability through general taxation, an ETS with free allocation and a narrow pricing scheme that covers just the energy and transport sectors.

4. In our view, while the government pays scenario can be the cheapest option, it has two key drawbacks. First, it does not introduce a price signal for carbon into the New Zealand economy. This means that firms face little incentive to change their production patterns, or to invest in emissions-reducing R&D. Firms need clear and consistent policy signals around the pricing of carbon so that they can make efficient long term investment decisions.[9] Second, it is an untenable political economy approach to emissions reduction in the longer term.[10] The global trend is clearly moving towards the gradual introduction of carbon pricing, albeit slowly and in varying forms.[11] Our understanding of the international climate change negotiations is that New Zealand would lose credibility if it was to shy away from carbon pricing. This is unlikely to benefit the country in the longer term – being 'outside the tent' is not a place that New Zealand can afford to be. Given our unique emissions profile, New Zealand needs to be at the table when post-2012 negotiations take place to ensure that our voice is heard and that the outcome is equitable. We cannot realistically do so if we do not have a commitment to a domestic carbon price.

5. We therefore recommend that the introduction of a carbon price is warranted. In the short run, a narrow based carbon pricing scheme (whether tax or trading scheme) at a low domestic price can provide this signal at a slightly lower economy wide cost than an all-industries, all-gases ETS with free allocation.

[9] Certainty could also be created through a commitment to have no carbon pricing in the foreseeable future, although we do not believe this is realistic from an international relations perspective.

[10] This is not a conclusion from our modelling results. It is a judgement based on our understanding of the international climate change negotiations.

[11] Putting a price signal in place gives the economy more time to transition to a lower carbon footprint.

6. The ETS, however, provides a price signal across the entire economy. And in the longer run, if the rest of the world takes action and technological improvements take place, our modelling shows that a broad based full price signal with no free allocation or exemptions is the least-cost way of meeting our post-2012 obligations.

7. With this long term scenario in mind, there would appear to be advantages, from a policy signalling and investment certainty perspective, of the government introducing an ETS in the short run as well. However, there are two key provisos related to competitiveness at risk and measurement costs, as explained in points 8 and 9.

8. Competitiveness at risk issues need to be considered. Until there is clearer evidence about the actions of the rest of the world and the nature of technological improvements, our modelling shows that there is value in designing any pricing scheme with some flexibility to prevent significant leakage or damage to key industries. Free allocation linked to output can be a cost-reducing mechanism of dealing with high costs of abatement and a lack of action by other countries (leakage and competitiveness at risk issues). Free allocation as compensation for stranded assets does not have this effect, though may be justified on equity grounds.[12]

9. If the aim of climate change mitigation policies is to change producers' behaviour, it is vital to be able to measure emissions in a cost effective manner. If the transaction costs of measuring emissions outweigh the benefits of emissions reduction, the policy may not be net welfare enhancing. Therefore the transaction costs of implementing an all-sectors all-gases ETS need to be evaluated. It may be advisable to exempt sectors such as agriculture where measurement costs are high relative to the benefit that would be gained from that sector's inclusion. Our modelling suggests that, in the short term, such exemptions do not reduce economy wide welfare.

10. On balance, **our recommendation in the short run is to introduce an ETS with free allocation to competitiveness-at-risk sectors, with agriculture excluded if measurement of its emissions is prohibitively expensive. Free allocation should be output-linked and phased out as our competitors adopt carbon pricing. If agriculture is initially excluded it should be transitioned into the ETS, with free allocation if required, as measurement becomes economic.**

[12] Modelling the likely change in economy wide costs from different types of free allocation is difficult until we are clear on their intent. Accordingly we encourage policy makes to be clear about what free allocation is intended to achieve and to design it accordingly.

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1. Objective of report

The broad objective of this report is to provide an analysis of the macroeconomic impacts of:

- The least-cost option for meeting any Kyoto liability
- The proposed Emissions Trading Scheme (ETS)
- A revenue-neutral tax on carbon or carbon equivalents, coupled with an equivalent subsidy for carbon sinks, or a tax on energy.[1]

This report is organised as follows. Section 2 outlines the scope of the research. Section 3 revisits previous economic modelling of the ETS and reconciles the differing results between earlier Infometrics and NZIER work. The theory and modelling approaches related to key elements of an ETS design, such as free allocation, technological change and the actions of the rest of the world, are explained in section 4, along with a summary of the modelling scenarios considered. The results of our modelling for the short term (2012) and long term (2025) are presented in section 5, and their implications discussed. The paper concludes with some recommendations regarding the least cost option for meeting our Kyoto liability.

2. Overarching assumptions

Given time and budget constraints, the scope of this research does not include any analysis of:

1. The science of global warming; whether it is occurring, what its economic and social effects might be, or whether reducing anthropogenic greenhouse emissions will mitigate it.

2. Non-market policies to reduce emissions, such as restrictions on thermal generation and biofuels obligations. They are no longer part of government policy and their merit in the presence of a carbon charge has not been proven.

3. What action consumers or governments in other countries might take against New Zealand if it was perceived that New Zealand was not doing enough to reduce emissions (such as green taxes, border tax adjustments or ‘food miles’ related preference changes[2]).

4. Specific industry, sectoral, household or regional impacts. These effects will differ considerably from the economy wide results presented in this paper – some will experience much larger economic costs and others will benefit. We

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[1] See Appendix B for the full terms of reference.

[2] On the latter, see Ballingall and Winchester (2009).

suggest that this more disaggregated analysis should be a particular focus for further research.

Furthermore, it is assumed that New Zealand will be part of any international emissions limitation agreement that may evolve beyond 2012.

3. Previous modelling of ETS policy

3.1 Introduction

Previous modelling of the economic and emissions impacts of the proposed New Zealand ETS has been carried out by a number of researchers. Such research looked at the impacts of an ETS, under various assumptions, on key economic variables such as employment and economic incomes. In some cases, the results of these modelling exercises were quite different in direction and magnitude.

This section provides an overview of the modelling technique (Computable General Equilibrium or CGE) that has been used to evaluate the ETS. It outlines some of the strengths and weaknesses of this technique.

It then discusses the results of previous CGE modelling work on the ETS by Infometrics (2008) and NZIER (2008) and reconciles some of the main differences. These variances are largely attributable to differing underlying assumptions contained within CGE models for the analysis of New Zealand climate change mitigation policy.

3.2 Discussion of CGE modelling

3.2.1 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).

3.2.2 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".[3] 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.

3.2.3 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

[3] The analysis in this report focuses on the macroeconomic (or economy wide) impacts of climate change mitigation policy in New Zealand. A detailed discussion of industry or regional effects is outside the scope of this research.

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 in section 3.3.3 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]").

3.2.4 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 asses 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-CO_2 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 inter-temporal 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.

3.2.5 Summary

Despite the caveats outlined above, we 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.

3.3 Reconciling modelling work on the New Zealand ETS

3.3.1 Studies considered

Infometrics have completed various analyses of the New Zealand ETS.[4] NZIER have published one analysis of the proposed ETS using a general equilibrium model ('A quantitative analysis of the proposed ETS', April 2008).

Both CGE modelling exercises considered the short run (to 2012) and long run (to 2025) impacts of the ETS, using a range of world carbon prices. Both models are similar in structure and use a common underlying database. However, there are some important differences in assumptions between the two pieces of work. Understanding these differences is crucial for understanding why the reports' overall conclusions about the economic impacts of an ETS differ.

[4] The main report in this regard is Infometrics. (2008). 'General Equilibrium Analysis of Options for Meeting New Zealand's International Emissions Obligations'. Report prepared for Emissions Trading Group.

3.3.2 Comparison of results

A comparison of short and long term results from the previous studies of the ETS is presented below. The results show the impacts of using an ETS to meet New Zealand's international obligation versus a scenario where New Zealand has no international obligation.

Table 1 Short run 2012 ETS impacts

	Infometrics $25	Infometrics $50	NZIER $15	NZIER $40 (1)
GDP	0.0	-0.1	-0.2	-0.5
Private consumption	-0.2	-0.3	-0.3	-0.8
Employment	NA	NA	-0.3	-1.0
Real wages	-0.2	-0.5	NA	NA
Real exchange rate	0.0	0.1	0.0	0.0
Emissions	-5.9	-10.1	-0.8	-2.6

Notes: (1) Note differences in assumed carbon price between Infometrics and NZIER
Source: NZIER, Infometrics

Table 2 Long run 2025 ETS impacts

	Infometrics $25	Infometrics $50	NZIER $15	NZIER $40 (1)
GDP	0.0	-0.2	-1.3	-2.1
Private consumption	-0.7	-2.2	-1.9	-3.0
Employment	NA	NA	NA	NA
Real wages	-0.7	-2.7	-4.3	-6.7
Real exchange rate	-0.4	-1.3	-1.1	-1.7
Emissions	-5.3	-16.4	-6.6	-10.4

Notes: (1) Note differences in assumed carbon price between Infometrics and NZIER
Source: NZIER, Infometrics

The tables highlight the key findings of the comparison:

- Both models show that the unilateral introduction of an ETS in order to meet our Kyoto and post-Kyoto international obligations leads to a fall in economic activity in the long run (or in the case of Infometrics' short run results, that activity does not rise).
- Both models show that private consumption (household spending) falls after an ETS is introduced, with these falls larger in the long run scenarios.
- Both models show that meeting our international obligations with an ETS has negative labour market effects versus the case of no international obligations, although the labour metrics reported vary due to differences in the closure assumptions used. The Infometrics model assumes aggregate employment is fixed in the short run, so that real wages fall. The NZIER model assumes real wages are fixed in the short run, so that employment falls by up to 1.0%. Both models assume real wages adjust in the long run.

- Both models suggest an ETS would have minimal impacts on the real exchange rate, particularly in the short run.
- Infometrics' modelling shows smaller reductions in GDP, private consumption and real wages than NZIER's modelling.
- Infometrics' short run emissions reductions are larger than NZIER's reductions; long run emissions reductions are reasonably similar.

3.3.3 Drivers of differences

Infometrics have completed a review of the NZIER modelling ('Review of NZIER Report', May 2008). As they noted then:

> *Differences will be caused by macroeconomic closure assumptions and a whole array of differences (some very minor) around the parameterisation of the model's production structures, demand functions, industry aggregation, energy substitution possibilities and so on.*

We focus here on the potential key drivers of the differences in results.

It is important to note that there are usually no "right" or "wrong" answers when discussing the assumptions that underpin differing modelling techniques. As explained in section 3.2, assumptions often differ between modellers. These differences reflect alternative views of how economies operate and how economic agents react to changes in prices, emissions mitigation possibilities, preferences and other variables. What is important is understanding why models differ and how these differences affect the results produced. This transparency and reconciliation removes some of the criticisms that are levelled at CGE models as being 'black boxes'.

a) Capital and labour closures

Table 3 below summarises the different closures employed in NZIER and Infometrics' earlier modelling of the ETS.

Table 3 Capital and labour closure assumptions

	Infometrics		NZIER	
	Short run	*Long run*	*Short run*	*Long run*
Capital	Fixed	Fixed	Fixed	Endogenous
Rate of return on Capital	Endogenous	Endogenous	Endogenous	Fixed
Labour supply	Fixed	Fixed	Endogenous	Fixed
Wages	Endogenous	Endogenous	Fixed	Endogenous

Source: NZIER, Infometrics

Infometrics use the same closure assumptions for short and long run analysis: the two factors of production, labour supply and the capital stock, are held fixed. Thus the modelling assesses, for a given size of the economy, how an ETS will affect economic welfare, via changes in allocative economic efficiency and the real exchange rate, and the terms of trade.

NZIER assumes sticky (fixed) wages in the short run, allowing labour supply to adjust to policy shocks. In the long run, NZIER's labour market closure is the same as that of Infometrics: the labour supply is fixed and real wages adjust.

NZIER's short run capital closure is identical to Infometrics'. The capital stock is fixed, and the rate of return on capital can vary. In the long run, NZIER fixes a rate of return on capital, allowing the capital stock to adjust. The Australian Productivity Commission (2008) notes that this is a standard long-run capital closure for policy analysis:

> *in a long-run CGE framework, it is common to assume that capital adjusts to changes in after-tax rates of return. In the long run, risk-adjusted rates of return are equalised across industries, and capital is reallocated to its best use, both domestically and internationally, once the economy has fully adapted to the modeled changes.*
>
> *This is the usual setting used in long-run comparative static models such as the ORANI model (Dixon et al. 1997) and the MMRF model (Adams, Horridge and Wittwer 2002), as well as in models developed and used by Econtech such as MM600+ (Murphy 2002). Similarly, in the more recent recursive dynamic models (including MONASH, USAGE, MM2 and GTEM), capital is allowed to adjust in the long run, usually with a lag. See, for example, Dixon and Rimmer (2002), Dixon et al. (2005) and Powell and Murphy (1997).*
>
> *These models have been used to simulate the effects of policy changes, including most notably, tariff reductions, and show that after several years of adjustment, the capital stock is bigger than under 'control' (BAU).*

The Australian Treasury's analysis of an ETS used three dynamic general equilibrium models, including the MMRF and GTEM models listed in the Productivity Commission's discussion above.[5] A standard feature of such models is that investment (capital) responds to changes in rates of return above or below baseline forecasts. That is, over time, a decrease in rates of return to capital versus baseline will result in less investment and a smaller capital stock.

Infometrics' view on long run capital movements is different. They believe that the aggregate level of investment in the economy is affected more by expectations of future demand and Keynes' "animal spirits" than by the rate of return. Consequently a small change in confidence can outweigh the effects of a change in the rate of return. This perspective takes into account the uncertainty surrounding how business confidence might be affected under a carbon charge. There is limited empirical evidence to draw on. It is possible that business confidence and investment might

[5] A dynamic model is one that explicitly examines the year-by-year adjustment path of an economy over time to a policy shock. In contrast, the comparative static models used by NZIER and Infometrics assume a start year (pre-shock) and an end year (post-shock), and cannot determine how variables adjust in any intervening period.

rise if climate change policy settings provide a clear signal of longer term government policy relative to a situation of policy wavering. Potential investment funds that are attracted by 'green initiatives' could outweigh investment foregone in carbon-intensive industries. However, the reverse might also apply. Infometrics' long run closure that holds the capital stock constant between scenarios reflects this uncertainty about firms' responses to climate change policy.

The implications of the different closures on the model results are significant. Infometrics' closure is likely to limit the impact that the ETS policy can have on GDP, as GDP is restricted by the closure assumption of fixed factors of production. Infometrics' GDP results may therefore understate the negative impacts of the ETS if an ETS has an adverse effect on the return to capital.

In the short-term, the NZIER closure assumptions assume employment can vary and that wages are sticky/fixed. In reality both will respond and the short term impacts of the ETS may therefore be overstated by the NZIER results.

Given the differences in closure assumptions, for previous work the private consumption metric is more comparable than GDP as a measure of economic welfare (or how 'well off' households are after the introduction of an ETS). Indeed the summary of results highlights that private consumption metrics are the most consistent between the two analyses.

Moving forward, Infometrics and NZIER have agreed that the most appropriate economic welfare measure for analysing the impacts of an ETS is Real Gross National Disposable Income (RGNDI). RGNDI measures the total incomes New Zealand residents receive from both domestic production and net income flows from the rest of the world (Statistics New Zealand, 1999), and adjusts for changes in the terms of trade. This is particularly pertinent for the analysis of policies to meet our Kyoto obligation, which will include a lump-sum offshore payment for excess emissions over our Kyoto allowance. RGNDI includes these effects in contrast to the GDP metric which provides an indicator of domestic production but does not capture the impact of international transfers and investment income.

b) Fiscal position closures

Both NZIER and Infometrics assume that the government's fiscal position does not change as a result of the ETS. This assumes the ETS is revenue neutral – any excess revenue generated by the ETS is returned to households via lower taxes. We note that Infometrics' modelling of households and income taxes is more detailed than NZIER's, and may contribute to minor differences in results between the two models. However the overall fiscal closure assumptions are the same and unlikely to be a major driver of differences in macroeconomic results.

c) External balance closures

The external balance closures, while differing in detail due to model structures, are not dissimilar. Both NZIER and Infometrics take the view that any Kyoto liability cannot simply be funded by running an increased external deficit. The payment of the Kyoto liability under both models is offset by increases in net exports, with associated changes in the exchange rate to maintain the current account balance as a proportion of GDP.

While the mechanisms differ slightly, the impact of the closures is the same, and as such is unlikely to be a major driver of results differences. The exchange rate results from both models are of very similar magnitudes.

d) Export elasticities

The export elasticity values used by NZIER are based on data from the Global Trade Analysis Project (GTAP), while Infometrics' are based on estimation work undertaken originally in Australia, and on in-house research on specific commodities. In general, NZIER's values are slightly higher than Infometrics' values. This means the NZIER analysis will be more sensitive to changes in the prices of export commodities induced by the ETS, while the Infometrics analysis will be relatively less sensitive. This is consistent with the different direction of the respective overall results. Ideally, both NZIER and Infometrics' models would use the same export elasticities. In practice however, export elasticities are not known with certainty and will always be approximations of how export markets actually work. Our assessment is that the impact of any differences in export elasticities between models is probably small relative to the effects of differences in macroeconomic closure.

3.4 Summary

This section has provided an outline of the economic modelling technique used to evaluate the impacts of a New Zealand ETS. We conclude that CGE modelling is an appropriate tool for such research, although as with any model, some important caveats should be noted.

We have also examined previous ETS modelling work by NZIER and Infometrics and discussed the reasons for the differences in results. The key point here is the researchers' respective assumptions regarding the model 'closure' as it relates to the growth and movement of capital. Other modelling differences are relatively minor.

An important outcome of this reconciliation process is that NZIER and Infometrics have agreed that the most appropriate measure of economic welfare should be Real Gross National Disposable Income (RGNDI).

Given this improved shared understanding of the NZIER and Infometrics models, and drawing on the comprehensive modelling exercise that took place in Australia as well as new research in New Zealand, we now re-run our models to examine the economic impacts of a New Zealand ETS (and alternative mitigation polices such as a carbon tax).

4. Scenario design: theory and practice

4.1 Introduction

Based on discussions with officials, NZIER and Infometrics designed and modelled a number of climate change mitigation policy scenarios, both in the short run (to 2012) and long run (to 2025)[6].

The various scenarios are designed to investigate the following issues:

- The government pays for permits using general taxation.
- A carbon tax versus an ETS (specifically a narrow based carbon tax on energy and transport, versus the ETS as proposed)
- Action (or inaction) by the Rest of the World (ROW) that might alter New Zealand firms' competiveness
- Technology improvements that are induced by imposing a price on carbon
- Free allocation
- The effects of including forestry.

In this section we outline the potential effects of these various issues in theory and discuss the approach we take to modelling them.

4.2 Tax vs. cap and trade

4.2.1 Theory

It is well known that a cap on emissions coupled with tradable emission rights (a Cap and Trade system, or CAT) will result in a price on emissions, and that an emissions tax set at the right rate would, under certain conditions, generate the same reduction in emissions (see for example, Chamberlain, 2009).

There is much debate on whether certainty about the amount of emissions is better than certainty about the price. As long ago as 1991 Nordhaus argued that the marginal cost of GHG reduction is likely to be a convex function, and that the marginal damage from warming reduces only slowly as emissions fall (which is not to say that there may not be a significant discontinuity or tipping point somewhere). If so, a small change in the cap could generate a large change in the price of emission rights and thus a large change in welfare, but a small change in an emissions tax would lead to only a very small change in emissions and thus a very small change in welfare.

Consequently the degree of price uncertainty associated with a cap and trade system is higher than the degree of quantity uncertainty associated with a tax. Or

[6] The year 2025 is taken as a proxy for 2030 (the year in which free allocation for trade-exposed industry and agriculture is phased to zero under the current legislation).

in other words, setting the cap at the wrong level is more likely to generate a welfare loss than setting the tax at the wrong rate, at least in the short term.

The Kyoto Protocol is based around country or country-block specific targets for emissions reductions. Emission reduction obligations are held by government, not by individual firms and citizens, so it is conceptually feasible for a country to be part of an international CAT system, but for its domestic policy to be a carbon tax. However, it is economically efficient for New Zealand emitters to face the same price as foreign emitters, so a carbon tax would need to be periodically adjusted. This may not provide any more price certainty than a fluctuating carbon price under a CAT system.

Either way, whether by a tax or a CAT, the objective is to reduce New Zealand's emissions. If emissions are not reduced sufficiently, New Zealand will need to purchase recognised emission permits from other countries on the international market. Under a carbon tax the government would purchase the permits. Under the proposed ETS individual companies would purchase them.

4.2.2 Modelling

The theoretical equivalence between a tax and CAT discussed above allows us to model any CAT scheme as a carbon tax. In practice, there are differences such as the impact of price uncertainty, complexity and administration costs, and ease of linkages to the international market, which we cannot accurately capture in our modelling framework.

If emissions do not fall by enough for New Zealand to meet its CP1 obligation the government purchases international permits using revenue from the carbon tax (or permit auctioning), after allowing for any free allocation. If the remaining revenue is insufficient, then in our modelling framework personal income tax rates are increased pro rata. Similarly any surplus revenue is used to reduce income taxes. Our models do not capture the complexities of progressive tax rates, Working for Families, rebates and so on.

4.3 Free allocation

4.3.1 Theory

The free allocation of emission rights in CAT schemes typically serves two purposes:

(i) Compensation for stranded assets

In the past businesses have invested on the basis that greenhouse gas emissions were free. Subsequently imposing a price on emissions could reduce the value of such investment, perhaps leading in some cases to stranded assets of structures and equipment that are specific to a certain industry rendered less competitive by an emissions price. An example might be a coal-fired power station or a dairy farm, but it is unlikely that the whole asset would become stranded. A reduction in value is more likely. Optimal compensation is via a once-only free allocation of emission rights (or an equivalent financial payment) equal in value to the change in asset value. There is no obligation on firms to remain in business, and new firms should not receive any free allocation, as they have no assets at risk.

(ii) Prevention of carbon and output leakage

Any introduction of a price on emissions in New Zealand that is higher than that in other countries could lead to leakage – firms reducing output in New Zealand, with the displaced output being produced in another country with a lower price on emissions. For example, an emissions price might make cement produced in New Zealand uncompetitive compared to imported cement. If this led to lower output from, or even the closure of, New Zealand cement plants, offshore plants would increase production to meet demand. New Zealand would meet its Kyoto obligation, but global emissions would not change, or could worsen.

Note that output leakage could also occur if general taxes are raised to pay for government purchases of emissions rights from offshore, although the size of the effect would likely be smaller as the incidence is shared economy wide rather than being concentrated in a few exposed sectors.

Free allocation under the proposed ETS is provided on the basis of ensuring against economic regret; namely that an industry once lost to New Zealand may not return, even if most other countries eventually impose a price on emissions.[7] Of course the regret could be the converse; where an industry is protected, but even in the long term could not compete internationally. Further empirical analysis to examine changes in international competitiveness over time would be required to identify which industries are worth protecting from an emissions price and which should simply be allowed to wither.

We can think of free allocation as being equivalent to the auctioning of emission permits with some of the revenue being handed back to particular industry groups. Any revenue that is handed back to industry is not available for reductions in income taxation.

An output subsidy to industry (provided in the form of free allocation) would not usually lead to a welfare gain. In the case of a carbon charge, however, the argument is more subtle. The welfare gain from less global warming is not captured in the model. This means that a carbon charge (tax or CAT) is effectively an arbitrary tax on some industries, manifested particularly in impaired international competitiveness, in which case free allocation ameliorates the distortion. However the model does capture the fact that lower emissions means that fewer emission permits need to be purchased offshore. So whether there is an economy-wide welfare gain from free

[7] The definition of economic regret could also include foregone investment and businesses closing down earlier than would otherwise have been the case.

allocation depends on whether ameliorating the negative effects of a distortionary tax and purchasing more permits, outweigh the benefit of undertaking more domestic emission reductions and purchasing fewer permits on the international market.

Further discussion on free allocation, in the context of the general equilibrium modelling results, is provided in section 5.2.4 below.

4.3.2 Modelling

Our understanding is that under the previously proposed ETS, assistance to firms is proposed to be in the form of a lump sum transfer initially based on 90% of 2005 emission levels, eventually declining to zero. The assistance is not linearly linked to production, but the firm must remain in business. This is essentially a hybrid of the two options discussed above. It is not compensation for stranded assets, but nor is it strictly tied to output. How should it be simulated in a CGE model? The two options discussed above lead directly to two modelling options.

1. Lump sum compensation is modelled as a wealth transfer to owners of the firm and has no effect on production or pricing decisions (and thus does not deal with economic regret). It is a transaction in the Income and Outlay account, not in the Production Account. In a CGE model the owners of industries are domestic households and foreign residents. Thus part of what households pay in the form of a price on carbon or higher income taxes is returned to them as dividends from industries that receive free allocation. There would likely be a reduction in economic welfare from such a churning of income due to transactions costs and the standard deadweight loss associated with taxation. However, our models understate these costs as transactions costs are excluded and income taxation is only crudely modelled.

   Payments to foreign residents represent an increase in net factor payments offshore. Under the models' closure rules the current account balance is not allowed to deteriorate, so any increase in net factor payments necessitates an increase in exports and/or a reduction in imports. This affects economic welfare in the models.

2. Compensation to prevent output leakage is modelled as an output subsidy. Recipients still face the full carbon price on their inputs, and so have an incentive to substitute gas for coal, insulation for energy and so on. However, to reduce the extent to which they must raise their output prices (which an internationally exposed industry may not be able to do without facing a reduction in demand) they receive a production subsidy. The subsidy could be a 100% offset to the firm's higher input costs, or a partial offset, in which case some leakage might still occur.

Free allocation under the proposed ETS has previously been modelled by both NZIER and Infometrics as a partial output subsidy. For example if a firm increased production by 20% between 2005 and (say) 2011, the free allocation would be equivalent to a subsidy of 75% of imputed 2011 emissions calculated on the basis of the emissions-output ratio that prevailed in 2005. Thus the firm would still have an incentive to reduce its emission intensity. If it could reduce its emission intensity by 25% the value of the free allocation would exceed the increase in input costs stemming from the carbon charge (ignoring second round effects). Whatever the final outcome, the free allocation is interpreted by the firm as a subsidy, and as such it enters into production and pricing decisions.

One might argue that free allocation under the proposed ETS will not be used by firms to mitigate price increases to customers. In that case modelling as per (1) would be appropriate.

For the purposes of calculating free allocation, emissions includes all emissions from the direct combustion of fossil fuels, all process emissions (which for agriculture includes methane and nitrous oxide emissions) and a deemed emissions factor for electricity of 0.6t CO_2/MWh.[8] Also, a pass-through of 100% of the carbon price is assumed even though this may not be the case, either in the GE models or in reality. Indeed e-dec (2005) argue that the pass-through will be less than 100% for natural gas, sub-bituminous coal and lignite.[9]

4.4 Forestry

Forestry is particularly difficult to model within the comparative static CGE framework used by both NZIER and Infometrics. Sohngen et al (2008) suggest capturing key features of forestry within CGE analysis requires detailed modelling of the land-use decision between competing uses, calculation of optimal rotation ages and average annual flows of timber.

Within the short timeframes of this research, we are unable to develop our respective models to tackle these issues. Ideally, the key impact we wish to capture is the increased level of activity within the forestry industry (as opposed to the planting of trees that are never harvested) in response to the effective industry subsidy provided by a price on carbon. In the BAU scenario to 2025 annual CO_2 net absorption by Kyoto forest is estimated at 11-12 Mt. At $25/tonne this equates to a producer subsidy equivalent of about 5%. Including this effect in the model (and simulating it as negative process emissions) leads to an increase in forestry output (harvested logs and tree growth) of about 4.5%. In terms of land area this implies around 90,000 ha. of additional plantation forest in a steady state situation. The macroeconomic benefit of this additional forestry activity is only around 0.1% of RGNDI.

Note that we expect a much larger increase in the conversion of marginal land to permanent forests. However, this impacts only on the net emissions projections within the model and not on forestry as an industry. That is, absorption of CO_2 by

[8] Source: Emissions Trading Group

[9] e-dec Limited (2005): *Emissions charge cost pass-through*, report to New Zealand Climate Change Office.

permanent forest simply reduces the number of emission units that New Zealand has to purchase offshore. It has the same effect as a change in New Zealand's international allowance.

4.5 Process emissions and technological change

4.5.1 Theory

Process emissions of greenhouse gases do not result from the combustion of fossil fuels, but from a chemical reaction of some sort. Examples are the calcination of limestone and the reduction of ironsand. A carbon price should encourage the development of technologies that reduce process emissions.

4.5.2 Modelling

In our modelling frameworks, process emissions also include emissions of methane and nitrous oxide from agriculture. Emission coefficients are expressed in terms of the quantity of emissions per unit volume of gross output. The models do not contain any endogenous technological response to a carbon price, although we look at the effects of some exogenously-assumed technological responses. Analysis of this issue is confined to longer term scenarios as new abatement technologies are unlikely to have a significant impact during the first commitment period.

Firstly, technology improvements are incorporated as in NZIER (2008). Abatement is passed through as an increase in the requirement for capital. This methodology is a realistic representation of how abatement occurs in practice: energy-saving abatement requires some investment in new capital e.g. housing insulation or a more efficient car. NZIER use a 20% improvement in agricultural emissions intensity, and a 10% improvement for the other major emitting industries, based on research into the abatement costs and opportunities available to New Zealand.

Secondly, the Infometrics scenarios explore the effects of two different types of technological change that could lower emissions of methane and nitrous oxides in farming, based on what the Ministry of Agriculture and Forestry consider to be plausible under a carbon price of $100 (or less) per tonne of $CO_{2.}$ The former scenario assumes reductions in methane emissions of 10% in dairy, beef and sheep farming, brought about by, for example, breeding for lower emissions, while the latter assumes reductions in nitrous oxide emissions of 11% in dairy farming, and 2% in sheep and beef farming, brought about by, for example, the use of nitrogen inhibitors.

Without technological change the only way that an industry can reduce process emissions is by reducing output. There is nothing inherently wrong with that as lower output from emissions intensive industries is one of the behavioural responses expected when a carbon charge is introduced, but the absence of a technological response could mean that the national costs of abatement are over-stated.

A consequence of modelling process emissions as being related to the level of output is that any free allocation of emission rights that is linked to output is directly offsetting. That is, a price on process emissions is modelled as an output tax while free allocation is modelled as an output subsidy. If the free allocation is 100% there is absolutely no net effect on production or pricing. However, if free allocation is modelled as compensation for a reduction in asset values, the carbon price would raise output prices.

4.6 Rest of world actions

4.6.1 Theory

As noted under the discussion on free allocation, carbon leakage can occur if New Zealand has a higher price on carbon than other countries. More specifically, New Zealand industries may suffer a loss in international competitiveness which could lead to reductions in output and carbon leakage if they compete in international markets against countries that have a lower carbon price or if they compete in New Zealand against imports from countries with a lower carbon price. Note that the existing pattern of trade may be a poor guide to the loss in competitiveness as market share – whether in New Zealand or in another country – could be lost to countries which currently do not compete with New Zealand. Furthermore the issue is industry or even commodity specific. Another country may have a similar price on carbon to that in New Zealand, but grant favourable treatment (such as by free allocation or exemption) to particular industries. This makes it extremely difficult to assess the degree to which the competitiveness of any particular industry in New Zealand is truly at risk, or for how long a period of time.

4.6.2 Modelling

Given the difficulty of deciding on which industries may be at risk and by how much, we model two extreme situations:

1. Our potentially most exposed industries (forestry processing, oil refining, hydrogen, glass, cement, steel, and aluminium, plus dairy products and meat products if CH_4 and N_2O are included) suffer a loss in competitiveness that is entirely determined by the carbon charge in New Zealand. This could be thought of as corresponding to a situation where foreign competitors or potential foreign competitors are totally sheltered from a carbon charge in their country.

2. World prices for goods produced by those industries rise by exactly the same amount as the rise in New Zealand prices caused by a carbon charge. Hence there is no loss of competitiveness. This is actually run as an iterative process that takes as its starting point for world prices, the prices of the at-risk commodities that result from running the models as in situation 1 above.

It may be assumed that these two extremes provide reasonable bounds for what the true situation might be in any given year or under any given future international agreement.

4.7 Government Pays

4.7.1 Theory

As discussed in section 4.3.14.3.1 the welfare gain from less climate change is not captured in the models' welfare functions. Other things equal, this means that a carbon price, be it an actual tax or a price in a CAT scheme reduces economic welfare; but other things are not equal. In particular a carbon price leads to a reduction in the cost of purchasing emission permits offshore by providing an incentive to reduce domestic emissions. A natural question to ask then is; is there an economically more efficient way to raise the revenue needed to purchase permits from offshore?

One such potential option is for the government to raise the finance from an increase in general taxation. We describe this as the 'government pays' scenario, although in fact it is taxpayers who pay. A small increment to existing tax rates across a wide base is generally more efficient than a selective tax on specific activities – given that the full benefit from addressing an externality is not in the welfare function. The downside to an increase in general taxation, however, is that there is no longer any domestic price signal to reduce emissions. With less domestic abatement the cost of purchasing international emission permits will be higher.

Thus the trade-off is between the allocative efficiency effects of different types of tax and the amount of national income transferred offshore. Our expectation is that even if the trade-off favours 'government pays' at a low international carbon price, as the price rises the opportunity cost of not reducing emissions increases.

4.7.2 Modelling

There are various ways in which government could raise revenue from general taxation. For modelling purpose we assume that all revenue would come from an equi-proportional increase in personal income taxes.

Other options are changes to GST or corporate taxes. Insofar as the latter is simply a withholding tax for domestic shareholders, this option would require a large increase in corporate tax rates, effectively raising the cost of financing investment from retained earnings and hence possibly reducing investment. We therefore assume that this is not a desirable option.

As probably New Zealand's least distortionary tax, raising GST is a possible option, but equity concerns may be more pronounced than under a rise in income taxation. This could quickly lead to debate about compensating changes in income tax for poorer households, a quagmire which is beyond the ambit of this report. As such, we do not consider this option.

4.8 Short run scenarios

In the short run ETS analysis, we investigate an ETS with coverage as previously proposed, at both $25 and $50 world carbon prices. We analyse a narrow based tax with a differential between domestic and world prices, recalling that in the short term a narrow based tax is similar to an ETS with exempt sectors, at least as so far as the modelling is concerned.

We do not investigate technology, the actions of the rest of the world (ROW) or endogenous forestry impacts. Note that the impact of forestry absorption of CO_2 on New Zealand's projected emissions path is simulated as a reduction in the number of emission permits that New Zealand has to purchase offshore. However, there is no endogenous subsidy to the Forestry industry that leads to an increase in commercial forestry.

We also include a government pays scenario whereby New Zealand meets its international obligation by purchasing permits offshore using revenue raised from general taxation.

Table 4 Short run ETS and Tax scenarios

Run #	1	2	4	5
Topic	Reference	Govt pays	Price Sensitivity	Narrow tax with price differential
World price	$25	$25	$50	$25
Domestic price	$25	$0	$50	$10
Coverage	Ag and Waste excl	N/A	Ag and Waste excl	Energy and transport
Free allocation	Yes	N/A	Yes	N/A
ROW	No	No	No	No
Technology	No	N/A	No	No
Forestry	Exog	Exog	Exog	Exog

Source: NZIER, Infometrics

4.9 Long run scenarios

In the long run, we add to the issues tackled in the short run, including considering the impacts of the ROW taking steps to price carbon (whereby international competitors also face a price on carbon), technology opportunities and endogenous subsidies to forestry. We investigate free allocation distributed as both a production subsidy and a lump sum. Free allocation is modelled as equal to 90% of projected 2025 emissions for the relevant industries and is available to new entrants if it is granted as a production subsidy to avoid output leakage.

The narrow tax in the reference case run (15) covers all electricity production and transport. We also look at scenarios where a carbon price in New Zealand differs from the world price by ±$15/tonne. In run (20), we consider a narrow tax on all energy and transport, with only process emissions are exempt.

The long run scenarios are outlined below in Table 5 and Table 6.[10] All scenarios have been discussed and agreed with the Ministry for the Environment. All scenarios include forestry, albeit in a fairly rudimentary fashion, and all revenue is recycled through lower personal income tax rates. Any excess emissions are accounted for through the New Zealand government purchasing credits at the world market price.

Table 5 Long run ETS scenarios

Run #	8	9	10	11	12	14	21	22
Topic	Reference	Assistance	Assistance	ROW	Tech	Price Sensitivity	Govt pays	Govt pays price sens.
World price	$25	$25	$25	$25	$25	$100	$25	$100
Domestic price	$25	$25	$25	$25	$25	$100	$0	$0
Coverage	Full	Full	Full	Full	Full	Full	N/A	N/A
Free allocation	No	90% Prodn subsidy[11]	90% Lump sum	No	No	No	N/A	N/A
ROW	No	No	No	Yes	No	No	No	No
Tech	No	No	No	No	Yes	No	N/A	N/A
Forestry	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog

Source: NZIER, Infometrics

Table 6 Long run carbon tax scenarios

Run #	15	16	17	18	19	20
Topic	Reference	Low domestic price: narrow coverage	High domestic price: narrow coverage	Low domestic price: full coverage	High domestic price: full coverage	
World price	$25	$25	$25	$25	$25	$25
Domestic price	$25	$10	$40	$10	$40	$25
Coverage	Electricity production and transport	Electricity production and transport	Electricity production and transport	Full coverage	Full coverage	All energy and transport
Free allocation	N/A	N/A	N/A	N/A	N/A	N/A
ROW	No	No	No	No	No	No
Technology	No	No	No	No	No	No
Forestry	Endog	Endog	Endog	Endog	Endog	Endog

Source: NZIER, Infometrics

[10] Note that Infometrics also consider some of the scenarios in these tables using an alternative assumption about whether the capital stock varies in the long run. These are designated in the results section with the notation (a).

[11] We also considered a 60% free allocation simulation, but do not report on it separately. The key conclusions for the 90% free allocation simulation (see 5.2.4) also hold true for the 60% simulation.

5. Modelling results and discussion

5.1 Introduction

The modelling work in this report was carried out by both Infometrics and NZIER, using a common set of policy scenarios and key assumptions. The models used – while similar in structure – are not identical, and therefore do not produce identical results. The models' differences are largely related to different industry and commodity aggregations and different database parameters. The latter reflects uncertainty over the precise nature of behavioural responses to changes in energy prices. As a result of these differences, we do not judge that it is appropriate to present a single set of modelling outcomes. To do so would require expressing a preference for one set of parameters or functional forms over others. We have no basis on which to make this decision.

All of the emission mitigation options are examined relative to a 'business as usual' (BAU) scenario. The BAU represents a picture of the economy and emissions without any carbon charges or international emission obligations. [12] It is an artificial construct as it is a world without Kyoto or any successor agreements, but this property makes it analytically very useful as all other scenarios tell us the cost – relative to BAU – of various ways of meeting our international obligations and under different assumptions about the exposure of our tradable industries.

New Zealand does not actually have the BAU option of ignoring Kyoto. Thus the costs we report in the tables below are actually the costs of signing up to Kyoto and using an ETS or a tax to meet the Kyoto obligations. They are not really the costs of an ETS or a tax *per se.*

Note further that the BAU does not take into account any of the possible climate change-related costs associated with adopting this scenario, such as trade barriers that might arise from non-participation or perceived inadequate action in the context of global efforts against climate change. We also do not consider the efficiency losses in the BAU due to the non-pricing of a negative externality.

Table 7 shows the models' BAU emissions.[13]

[12] The models' projections of the economy in 2011/12 or 2024/25 are similar to those produced by the MED in *New Zealand's Energy Outlook to 2030.* Without a price on carbon, emissions are about 10% above MED/MfE gross projections (due primarily to faster growth in emissions from agriculture and transport) but below MfE's net emissions.

[13] The composition of BAU emissions differs slightly between models, but the key figure – New Zealand's 2025 obligation – is very similar.

Table 7 Business as usual net emissions
Mt of CO2e

	Infometrics	NZIER
2012	70.1	71.3
2012 International allowance	61.0	61.9
2012 NZ obligation	9.1	9.4
2025	111.6	125.3
2025 international allowance	50.0	61.9
2025 NZ obligation	61.6	63.4

Source: NZIER, Infometrics

New Zealand's obligation under CP1 means that in the BAU about 9.1 to 9.4 Mt of emissions per annum need to be reduced domestically or covered by the purchase of emission permits in the international market. These figures are estimated after allowing for any forestry absorption of emissions.

For 2025 we do not know the specifics of any international agreement. Infometrics assume that New Zealand will have an allowance of 50 Mt, implying that in the BAU we are responsible for about 62 Mt. NZIER assume an allowance of 61.9 Mt, and an international obligation of approximately 63 Mt. New Zealand's net international obligation is the key parameter in determining the overall level of the impact of New Zealand signing an international agreement, and on this parameter NZIER and Infometrics are virtually identical.

In addition to the allowances from future international agreements, New Zealand's international obligations are dependent on future 'base case' emissions. This can vary significantly due to influences such as:

- Weather conditions e.g. drought impact on agricultural emissions
- Economic conditions e.g. the impact of the global financial crisis on the demand for New Zealand's exports (and thus the emissions associated with them)

While these sometimes random and difficult-to-predict events influence the overall *level* of impacts, key trends and results around the *relativities* of various policy options are not directly affected.

The discussion of scenario results is based on a comparison to a reference case, so that the direction and magnitude of impacts due to each change in policy assumptions can be more easily understood. The reference case choice is not our preferred case. It is simply a benchmark. In the long run scenarios, we take simulation 8 (see Table 5) as our reference. This scenario has a $25 carbon price, includes forestry, does not include action by the rest of world, has no free allocation and does not incorporate any technological change.

We have not been asked to examine the regional and industry impacts of an ETS or carbon tax. We are most interested in this report in the least cost macroeconomic option. We recognise that some regions and industries will be more severely impacted – primarily those which are carbon-intensive producers with few abatement options, and the regional economies that rely on these industries.[14]

5.2 Long run results

5.2.1 ETS impacts

Table 8 ETS long run impacts at different world carbon prices

Run #	8	8a	14	8	14
Description	Reference: $25 price; no tech change; no RoW action; no free allocation	Reference (8) but alternative capital closure – see note (2)	As (8) but $100 price	Reference $25 price; no tech change; no RoW action; no free allocation	As (8) but $100 price
Model	Infometrics	Infometrics	Infometrics	NZIER	NZIER
Price	$25	$25	$100	$25	$100
Real GDP	-0.6	0.0	-2.1	-0.7	-2.7
Real GNDI	-0.9	-0.4	-3.0	-1.1	-3.5
Real Private Consumption	-1.1	-0.7	-3.7	-1.2	-3.7
Real wages	-1.5	-0.7	-5.3	-2.6	-9.7
Real exchange rate	0.0	-0.4	0.0	1.0	2.9
Emissions	-4.3	-4.0	-14.4	-5.5	-21.3

Notes: (1) All results %change from BAU unless otherwise stated
(2) Alternative capital closure fixes capital rather than the rate of return (see section 3.3.3a)

Source: Infometrics, NZIER

Under the reference scenario (8) the impact of the ETS ranges from -0.9% of RGNDI at low prices of carbon rising to -3.5% at higher prices of carbon. The real wage declines by between 1.5% and 2.6% at a low price of carbon, rising to -5.3% to -9.7% at higher prices of carbon.

The benefit of the ETS is that it induces emissions reductions of approximately 5% of total emissions or around 6 million tons CO_2e. This reduces New Zealand's international obligation slightly to approximately 50 million tons CO_2e. However, even under an ETS, the reduction in domestic emissions is small: New Zealand (private and public sector combined) still purchases the vast majority of its emissions reductions from offshore.

At a higher world price of $100, the ETS induces emissions reductions of between 14% and 21%. However, to meet its international obligations New Zealand still purchases the majority of its emissions reductions offshore.

Comparing our modelling work with that carried out in Australia is fraught with difficulty due to the use of different models, scenarios, assumptions and databases[15].

[14] Refer to NZIER (2008) and Infometrics (2008) for a discussion of some of these impacts.

However the general results suggest that GNP per capita would be between 1.3% to 2.5% lower than in the reference case by 2020. Consumption (defined as private plus government consumption) would be between 1.1% and 1.6% lower over the same time period according to the MMRF and GTEM models, with far smaller impacts when the G-Cubed model is used.

5.2.2 Impacts of technological change

Table 9 Technology scenario versus reference ($25)

Run #	14a	12a	12a	8	12
Description	$100 price; no tech change; no RoW action; no free allocation; alternative capital closure – see note (2)	As (14) but with abatement tech change for CH_4	As (14) but with abatement tech change for N_2O	$25 price; no tech change; no RoW action; no free allocation	As (8) but with tech change in intensive sectors
Model	Infometrics	Infometrics	Infometrics	NZIER	NZIER
Price	$100	$100	$100	$25	$25
Technology	No	CH_4	NO_2	No	Yes
Real GDP	-0.1	-0.2	-0.1	-0.7	-0.6
Real GNDI	-1.4	-1.2	-1.3	-1.1	-1.0
Real Private Consumption	-2.2	-2.0	-2.1	-1.2	-1.1
Real wages	-2.7	-2.6	-2.6	-2.6	-2.5
Real exchange rate	-1.3	-1.1	-1.2	1.0	0.9
Emissions	-13.2	-17.6	-15.8	-5.5	-8.3

Notes: (1) All results %change from BAU unless otherwise stated
(2) Alternative capital closure fixes capital rather than the rate of return

Source: Infometrics, NZIER

The technology scenarios, as outlined in section 4.5.2, highlight two important factors. Firstly, technology mitigates but does not prevent economic welfare losses, relative to the reference case (8). In the NZIER scenario the improvement in real GNDI from technology change is only 0.1 percentage point, as technology is not free but comes at an investment cost (the cost of investing in some new abatement technology e.g. a new light bulb). In addition, technological improvements of the order of those assumed here (between 10 and 20%) do not alleviate all or even the

[15] The Australian modelling work used a number of different models. We report the results from the MMRF, GTEM and G-Cubed models. The scenarios examined (Australian Treasury, 2008, p.75) are as follows: The Garnaut -10 and CPRS-5 scenarios are consistent with stabilisation at around 550 ppm CO2-e in 2100. The CPRS -15 scenario is consistent with stabilisation at around 510 ppm CO2-e in 2100. The mitigation scenarios use global market-based policy mechanisms to reduce global emissions. The Carbon Pollution Reduction Scheme (CPRS) scenarios assume multi-stage global action: economies gradually join a global emissions trading scheme from 2010 to 2025. The Garnaut scenarios assume unified global action from 2013: all economies participate in a global emissions trading scheme that covers all sources of greenhouse gas emissions. The Garnaut scenario assumes all gases, all sectors; the CPRS exclude agriculture to 2015.

majority of the cost of carbon on firms, but make some relatively small proportional reduction. However should technology deliver the 'silver bullet' that can drastically cut emissions, we would expect the impact of the ETS on the economy to fall. In the Australian modelling work (Australian Treasury, 2008), carbon capture is such a silver bullet that reduces domestic costs by 25%. In the New Zealand context, technology that can significantly reduce methane emissions is likely to significantly reduce the cost to the domestic economy.

Secondly, technology delivers a large increase in emissions reductions for a lower cost to the economy. NZIER's example shows an increase of 2.8% in emission reductions, while Infometrics scenarios show increases of 2.6% to 4.4%. Technology reduces the economy-wide cost of abating. This has significant repercussions for the design of a least cost scheme to meet New Zealand's international obligations which we discuss in the following sections.

5.2.3 Impacts of rest of world's actions

Table 10 ROW versus reference ($25)

Run #	8	11	8	11
Description	$25 price; no tech change; no RoW action; no free allocation	As (8) but RoW takes action;	$25 price; no tech change; no RoW action; no free allocation	As (8) but RoW takes action;
Model	Infometrics	Infometrics	NZIER	NZIER
ROW	Out	In	Out	In
Real GDP	-0.6	-0.4	-0.7	-0.3
Real GNDI	-0.9	-0.6	-1.1	-0.5
Real Private Consumption	-1.1	-0.7	-1.2	-0.5
Real wages	-1.5	-1.0	-2.6	-1.8
Real exchange rate	0.6	0.4	1.0	0.1
Emissions	-4.3	-3.0	-5.5	-3.0

Notes: (1) All results %change from BAU unless otherwise stated
Source: Infometrics, NZIER

Compared to the reference case, ROW action significantly reduces the negative impact of the ETS. NZIER show that the economic welfare loss as measured by real GNDI is reduced from -1.1% to -0.5%, while Infometrics show improvements from -0.9% to -0.6%. New Zealand's emissions reductions are lower, but other countries share the burden more equitably. Trade-exposed industries are no longer at a competitive disadvantage, and output leakage tends towards zero.

As discussed in section 4.6, a price on carbon in New Zealand if not matched by other countries will reduce our international competitiveness. Accordingly, when the rest of world takes action, thereby (partly) restoring our competitiveness, the national cost of buying emission permits on the international market falls. At the margin therefore it is welfare enhancing to undertake a little less domestic abatement and instead purchase more permits. Hence RGNDI falls by less than in scenario (8).

New Zealand's unique emissions profile means it is particularly influenced by action from the ROW. Most Annex 1 countries considering carbon pricing do not face such critical carbon leakage issues, because their emissions are dominated by non-tradable industries such as energy and transport. However this is not the case for New Zealand. Agriculture accounts for around 50% of emissions, but around 90% of dairying and sheep and beef produce is exported. A study of New Zealand's trade emissions (Andrew et al 2008) shows that New Zealand exports around 55% of total domestically produced emissions, yet imports an amount equal to just 25% of domestic emissions. It is therefore important for New Zealand that the ROW takes action with respect to carbon pricing, or domestic firms will be put at a competitive disadvantage relative to international competitors.

Our results align with those from Australia: "Strong coordinated global action reduces the economic cost of achieving environmental objectives, reduces distortions in trade-exposed sectors, and provides insurance against climate change uncertainty" (Australian Treasury, 2008, p195).

Note that the above scenarios assume that action by the ROW does not affect the international price of carbon. Whether there would be an effect on price depends on the total world emissions cap, which is beyond the scope of this report to investigate.

5.2.4 Impact of free allocation: production subsidy

Table 11 Free allocation versus reference ($25)

Run #	8	9	8	9
Description	$25 price; no tech change; no RoW action; no free allocation	As (8) but 90% free allocation as production subsidy;	$25 price; no tech change; no RoW action; no free allocation	As (8) but 90% free allocation as production subsidy;
Model	Infometrics	Infometrics	NZIER	NZIER
Free allocation	0	90%	0	90%
Real GDP	-0.6	-0.5	-0.7	-0.3
Real GNDI	-0.9	-0.9	-1.1	-0.9
Real Private Consumption	-1.1	-1.4	-1.2	-1.0
Real wages	-1.5	-1.2	-2.6	-1.4
Real exchange rate	0.6	0	1.0	0.3
Emissions	-4.3	-4.0	-5.5	-1.9

Notes: (1) All results %change from BAU unless otherwise stated

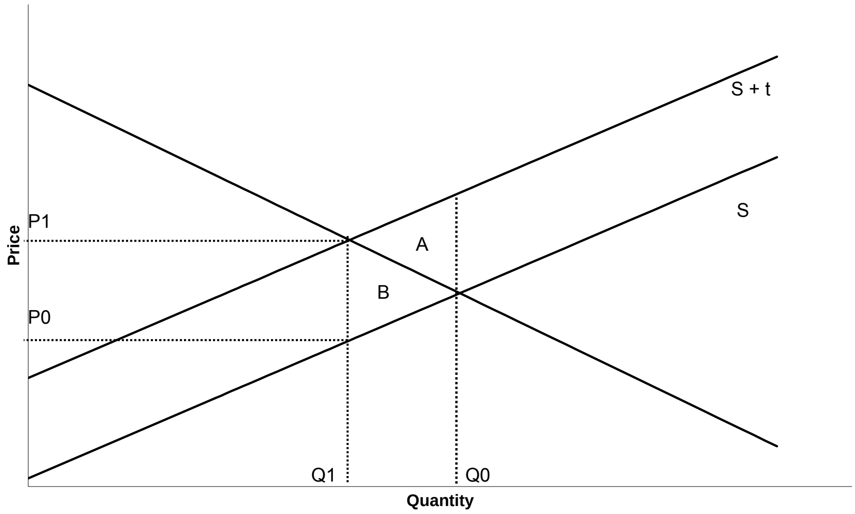
Source: Infometrics, NZIER

The macroeconomic impact of a production subsidy-type free allocation is small. Infometrics show no change in the RGNDI welfare measure; NZIER show free allocation is slightly welfare improving compared to the reference scenario assumptions (no endogenous technological change; no action by the RoW, and a low carbon price). Under the assumption of fixed total capital stock neither model shows a welfare difference between free allocation and no free allocation (model runs not shown)

The results are not immediately intuitive. The economy wide effect of free allocation is an important example of how general equilibrium analysis differs from partial equilibrium techniques. The standard partial equilibrium analysis shown in Figure 4 confirms this. Imposing an ETS pushes up the supply curve moving production from Q0 to Q1. The dead weight loss from this tax is area B. However this is offset by the social benefit of reducing emissions: areas A + B. The net result is that the ETS is welfare enhancing by the area A.

Free allocation (which reduces the size of the tax) moves output back towards point Q0 and thus comes at the cost of the area A. If the story ended there, free allocation would be unambiguously welfare reducing.

Figure 4 Partial equilibrium analysis



Source: NZIER

Partial analysis, however, does not consider the flow-on effects that changes in one industry have on the rest of the economy, and this matters in a scheme that affects not just the marginal firm but the whole economy. A reduction in output by an industry impacts on the factor markets. The producing industry now needs less capital and labour. Less demand for labour decreases wages to employees, which in turn reduces private consumption. Less capital means a smaller productive economy. There are flow-on effects as the commodity price rise flows through the economy. All of these lead to lower economy-wide welfare.

Free allocation alleviates these negative general economy effects. Thus while a partial equilibrium analysis shows a welfare reduction from free allocation, an economy-wide or general equilibrium analysis might not. The balance lies between the cost to the economy of reducing New Zealand's emissions versus the cost to the economy of purchasing international emission permits. If the economy-wide cost of reducing an extra unit of emissions is greater than the benefit of buying fewer international permits, then free allocation can be welfare enhancing.

The modelling technique we have employed in this analysis captures the general equilibrium effects. The results show that the balance is borderline. Infometrics show no macroeconomic difference for scenarios with free allocation versus without free allocation. NZIER show slight gains from free allocation.

a) What influences the balance?

The opportunity cost of emissions reductions is simply the world price. Every unit of emissions New Zealand reduces domestically saves the purchase of a unit from offshore.

The general equilibrium impacts are dependent on a number of factors:

- The supply and demand curves for the respective industry – a flat demand curve will mean the tax has little impact on the price of the commodity but large impact on output
- The emissions-intensity of the industry. High emissions intensity means the impact on the supply curve will be large. Any improvements in abatement technology will lower the impact
- Rest of the World response
- The ability of industry/economy to substitute – industries where alternatives to emissions-intensive commodities can be easily sourced will be less impacted.

We provide two generic commodity examples, electricity and dairy products, to highlight particularly the above points.

Coal-generated electricity production is an emissions intensive industry. Imposing a charge on carbon will therefore have a large impact on the supply curve for electricity produced from coal. In reality and in our modelling, electricity produced using coal can be substituted by electricity produced using renewables. This lowers the impact of the higher price of coal-generated electricity. In demanding more renewable-generated electricity, the renewable sector expands which has a positive influence on the factor markets. The renewable sectors increase demand for capital and labour, which offsets the reduced demand for capital and labour within the coal powered generator industry. The general equilibrium effects of emissions reductions in the coal industry are therefore likely to be relatively low.

In contrast, take a dairy commodity which is exported. Exports in the models face a downward sloping demand curve – an increase in price lowers demand. In this instance, international consumers substitute away from New Zealand exports to imports from other countries. In the general equilibrium framework, this increases the demand for capital and labour in that country, but not in New Zealand. The increase in price of the local commodity does not benefit another local commodity, thus the negative impact on the domestic factor markets is relatively larger.

b) The impact of the assumptions around the capital stock

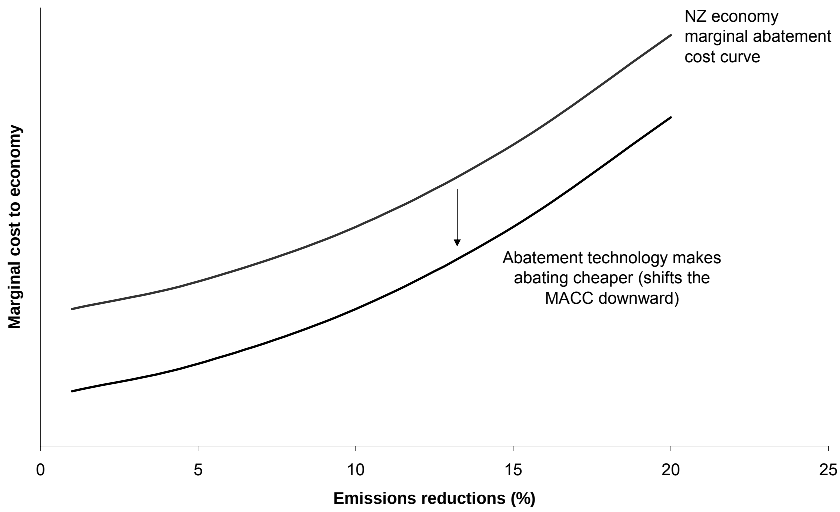
In the above analysis, we have argued that the general equilibrium effects on the capital stock are a negative by-product of a tax on production. To confirm this, we investigate a simulation with a long-run closure rule that holds capital stocks fixed, and instead allow rates of return to vary. Essentially we eliminate this negative effect on capital by assuming capital stocks cannot contract. As noted above, the results of this scenario show that free allocation is no longer welfare improving.

c) Effective New Zealand economy-wide marginal abatement cost curve

The discussion in the previous section can be simplified into thinking of an effective New Zealand economy-wide marginal abatement cost curve. This curve simply shows the economy-wide cost of domestic emissions reductions, ignoring any international obligations. As per the above discussion, the curve is dependent on a number of factors:

- The industry or industries doing the abating – the economy-wide cost of abatement will be different for different industries. The substitutability of commodities is important, as is the total proportion of emissions that an industry contributes to total New Zealand emissions.
- The response of the ROW – should ROW price carbon, the economy-wide costs of abatement will be lower as New Zealand exports are not at a competitive disadvantage
- The abatement technology assumptions – improvements in abatement technology allow abatement at a lower cost to the economy

Figure 5 Economy-wide MACC: impact of technology



Source: NZIER

d) Summary of production subsidy free allocation issues

When the cost to the economy of abating is high, providing free allocation can be a lower cost option of meeting New Zealand's international obligations, depending on the capital closure rule. Technology improvements and action from the ROW lowers the costs of abating domestically, and tilts the balance in favour of a broad-based scheme with no free allocation. However in the interim period, while technology is developing and the ROW is still determining its response, our general equilibrium models show that free allocation can be welfare improving. These results are consistent with the Australian review's general equilibrium analysis of free allocation or shielding (Australian Treasury 2008):

> *This suggests the shielding arrangements proposed in the Carbon Pollution Reduction Scheme Green Paper could ease the transition to a low-pollution future for the shielded sectors.*

5.2.5 Impact of free allocation: lump sum payment

Table 12: Free allocation: lump sum versus production subsidy

Run #	8	9	10
Description	$25 price; no tech change; no RoW action; no free allocation	As (8) but 90% free allocation as production subsidy;	As (8) but 90% free allocation as lump sum subsidy;
Model	Infometrics	Infometrics	Infometrics
Free allocation method	None	Subsidy	Lump Sum
Free allocation	0	90%	90%
Real GDP	-0.6	-0.5	-0.7
Real GNDI	-0.9	-0.9	-1.1
Real Private Consumption	-1.1	-1.4	-1.8
Real wages	-1.5	-1.2	-1.5
Real exchange rate	0.6	0	-0.1
Emissions	-4.3	-4.0	-4.4

Notes: (1) All results %change from BAU unless otherwise stated

Source: Infometrics

The results show a worse effect on RGNDI if free allocation is modelled as a lump sum payment to industry with no impact on production and pricing. This is primarily because these subsidies are returned to business owners, many of whom reside overseas. We estimate that about 38% of the value of the free allocation would be remitted overseas, implying a reduction in RGNDI. Given the models' constraint on the balance of payments, this implies an increase in net exports, leaving fewer resources available for private consumption.

Not surprisingly, with no effects on pricing and production, the exposed industries lose market share and the reduction in emissions is similar to having no free allocation.

These results underlie the need to be clear about what free allocation is intended to address – compensation for lower asset values, exposure to international competition (and carbon leakage), or a clearly defined concept of minimum regret.

5.2.6 Narrow carbon tax versus ETS (at same carbon price)

Table 13 Narrow carbon tax ($25)

Run #	8	15	20	8	15	20
Description	$25 price; no tech change; no RoW action; no free allocation	As (8) but narrow tax on electricity production and transport instead of ETS	As (8) but narrow tax on all energy and transport instead of ETS	$25 price; no tech change; no RoW action; no free allocation	As (8) but narrow tax on electricity production and transport instead of ETS	As (8) but narrow tax on all energy and transport instead of ETS
Model	Infometrics	Infometrics	Infometrics	NZIER	NZIER	NZIER
Tax	ETS	Narrow Tax A	Narrow Tax B	ETS	Narrow Tax A	Narrow Tax B
Real GDP	-0.6	-0.4	-0.5	-0.7	-0.3	-0.3
Real GNDI	-0.9	-1.0	-1.0	-1.1	-0.9	-0.9
Real Private Consumption	-1.1	-1.2	-1.3	-1.2	-1.0	-1.0
Real wages	-1.5	-0.8	-0.9	-2.6	-1.2	-1.4
Real exchange rate	0.6	-0.2	-0.2	1.0	-0.4	0.4
Emissions	-4.3	-1.6	-2.4	-5.5	-1.6	-1.9

Notes: (1) All results %change from BAU unless otherwise stated
Source: Infometrics, NZIER

Tax schemes are generally seen to have flexibility in coverage, although there is no reason why an ETS could not be narrow in coverage. In run (15), we investigate a narrow carbon pricing scheme on electricity production and transport and compare it to a broad based scheme (such as the ETS). Infometrics find a narrow-based scheme is slightly welfare reducing relative to a broad-based scheme, decreasing real GNDI by 0.1%. By contrast, NZIER find the narrow-based scheme is slightly welfare improving, increasing real GNDI by 0.2%.

In run (20), we investigate a slightly broader narrow scheme that covers all energy use and transport. Not surprisingly this leads to a larger reduction in domestic emissions than obtained in run (15). However, the change in real GNDI is the same as in run (15). There are two ways to interpret this result. Slightly widening the narrow scheme does not improve welfare so there is no reason to impose the cost of carbon on further industries. On the other hand, if the longer term objective is an economy-wide carbon price, the results suggest there is no welfare loss at the macroeconomic level from including all energy uses rather than only electricity production.

More generally, the discussion surrounding free allocation is applicable to the analysis of a narrow-based carbon scheme. The opportunity cost of a narrow-based scheme is emissions reductions in exempted sectors. However, including an industry where the costs of abatement are high may outweigh the benefits of reduced emissions. In the NZIER model, the balance suggests that the costs of abatement are slightly higher than the gains from emissions reductions; the Infometrics model finds the benefits of reduced emissions slightly outweigh the costs of abatement. This does not suggest the models are widely disparate, but that the economy wide marginal abatement cost curves (MACC) differ between the models. This is to be expected given the range of different structures and substitution possibilities within the models.

More importantly, the results trend in the same direction given changes to parameters surrounding the view of the world. Technology improvements and action from the ROW lowers the costs of abating domestically, and tilts the balance in favour of a broad-based scheme with no free allocation. A narrow-based tax scheme becomes the definitively more costly option as technology delivers abatement opportunities and there is action from the ROW. However in the interim period, while technology is developing and the ROW is still determining its response, a narrow based taxation option may be lower cost than a broad-based ETS.

5.2.7 Narrow carbon tax and differential to world price

Table 14 Narrow carbon tax with differential to world price

Run #	15	16	17	15	16	17
Description	Narrow tax; no tech or ROW action	As (15) but lower domestic price	As (15) but higher domestic price	Narrow tax; no tech or ROW action	As (15) but lower domestic price	As (15) but higher domestic price
Model	Infometrics	Infometrics	Infometrics	NZIER	NZIER	NZIER
Tax	Narrow tax	Narrow tax	Narrow tax	Narrow tax	Narrow tax	Narrow tax
Domestic Price	$25	$10	$40	$25	$10	$40
World Price	$25	$25	$25	$25	$25	$25
Real GDP	-0.4	-0.4	-0.5	-0.3	-0.2	-0.3
Real GNDI	-1.0	-1.0	-1.0	-0.9	-0.9	-0.9
Real Private Consumption	-1.2	-1.3	-1.2	-1.0	-1.0	-1.0
Real wages	-0.8	-0.6	-1.0	-1.2	-0.8	-1.6
Real exchange rate	-0.2	-0.4	-0.1	0.4	0.6	0.2
Emissions	-1.6	-0.7	-2.5	-1.6	-0.5	-2.6

Notes: (1) All results %change from BAU unless otherwise stated
Source: Infometrics, NZIER

Under a taxation scheme, the taxation rate may be higher or lower than the world price. We investigate the macroeconomic consequences of both possibilities and find that there are no discernable welfare differences. Both models show no change in real GNDI with domestic prices higher or lower than the world price.

This is explained by analysing the emissions reductions. In 2025, New Zealand's international obligation is just over 50% of its total emissions. The narrow-based tax induces domestic emissions reductions of 1.6%, leaving around 49% to be purchased offshore. Thus varying the price of domestic emissions has little impact on the overall cost of the total emissions obligation, as this is dominated by purchasing emissions offshore at the world price. It follows that at higher world prices, any given domestic price differential will have larger negative welfare effects.

5.2.8 Broad based tax and differential to world price

Table 15 Broad based carbon tax with differential to world price

Run #	8	18	19	8	18	19
Description	Broad tax; no tech or ROW action	As (8) but lower domestic price	As (8) but higher domestic price	Broad tax; no tech or ROW action	As (8) but lower domestic price	As (8) but higher domestic price
Model	Infometrics	Infometrics	Infometrics	NZIER	NZIER	NZIER
Domestic Price	$25	$10	$40	$25	$10	$40
World Price	$25	$25	$25	$25	$25	$25
Real GDP	-0.6	-0.4	-0.8	-0.7	-0.4	-1.0
Real GNDI	-0.9	-0.9	-0.9	-1.1	-1.0	-1.3
Real Private Consumption	-1.1	-1.1	-1.1	-1.2	-1.1	-1.4
Real wages	-1.5	-0.8	-2.1	-2.6	-1.4	-4
Real exchange rate	0.0	-0.3	0.2	1.0	0.8	1.3
Emissions	-4.3	-1.8	-6.7	-5.5	-2.0	-8.5

Notes: (1) All results %change from BAU unless otherwise stated
(2) A broad based tax is equivalent to a broad based ETS with the same design features

Source: Infometrics, NZIER

A broad based tax with a domestic price lower than the world price is very similar to a broad based ETS with free allocation. NZIER show a welfare loss from higher domestic prices, and a welfare gain from lower domestic prices; Infometrics show little significant difference between the runs.

5.2.9 Government pays

Table 16 Government pays

Run #	8	21	14	22	8	21	14	22
Description	$25 price; no tech change; no RoW action; no free allocation	Govt pays	As (8) but $100 price	Govt pays as (21) but $100 price	$25 price; no tech change; no RoW action; no free allocation	Govt pays	As (8) but $100 price	Govt pays as (21) but $100 price
Model	Infometrics	Infometrics	Infometrics	Infometrics	NZIER	NZIER	NZIER	NZIER
Domestic Price	$25	$0	$100	$0	$25	$0	$100	$0
World Price	$25	$25	$100	$100	$25	$25	$100	$100
Real GDP	-0.6	-0.2	-2.1	-1.0	-0.7	-0.2	-2.7	-0.8
Real GNDI	-0.9	-0.9	-3.0	-3.7	-1.1	-0.9	-3.5	-3.6
Real Private Consumption	-1.1	-1.1	-3.7	-4.6	-1.2	-1.0	-3.7	-4.1
Real wages	-1.5	-0.1	-5.3	-1.2	-2.6	-0.5	-9.7	-2.2
Real exchange rate	0.0	-0.4	0.0	-2.0	1.0	0.7	2.9	2.7
Emissions	-4.3	0.1	-14.4	0.0	-5.5	0.2	-21.3	0.9

Notes: (1) All results %change from BAU unless otherwise stated
(2) A broad based tax is equivalent to a broad based ETS with the same design features
Source: Infometrics, NZIER

At low prices of carbon, the government pays scenarios result in similar welfare outcomes as the reference case (all sectors all gases ETS with no free allocation or ROW involvement). Infometrics shows no difference in RGNDI while NZIER shows a slight benefit relative to the reference case. As the price of carbon increases, both models show that an ETS becomes the cheaper option. This is because the opportunity cost of domestic emissions reductions increases as the price of carbon increases – that is, New Zealand has more to gain from domestic emissions reductions. We note however that the aggregation bias of the models may not fully capture the impacts of a high price of carbon on industry (e.g. if the price rises above a certain 'tip' point that shuts down large sections of industry).

5.2.10 The economy-wide cost of mitigation

Bringing together the above results, there are three types of costs that New Zealand incurs in meeting an international emissions obligation:

1. The cost of buying international emission permits, which is essentially a transfer of New Zealand income to foreigners.
2. The cost of moving the economy to less carbon-intensive products and processes, induced by a price on emissions.
3. The cost of a decline in international competitiveness.

In reality (3) is a subset of (2), but it useful to consider them separately. As shown in Table 10, using RGNDI as the welfare metric, the removal of (3) via the rest of the world fully entering a global trading system reduces the cost of meeting a given international obligation by between one third and a half (depending on the model). Another way to remove or at least soften the decline in competiveness is via free allocation as a production subsidy. Table 11 shows that this route reduces the cost of meeting a given international obligation by up to about one fifth. The fact that this mechanism has any potential at all to reduce costs, contrary to what one might expect, was discussed in section 4.3.1.

From the above scenarios we cannot accurately identify the sizes of (1) and (2), but in all scenarios most of New Zealand's international obligation is met via the purchase of permits, not by lower domestic emissions which, in Scenario 11 for example (refer Table 10) fall by only 3%. This suggests that the cost of buying permits is much less than the cost of anything other than a small amount of domestic abatement. Why is this? As discussed in Section 4.3.1 a price on carbon has the same negative effects on economic efficiency as any other distortionary tax. These negative effects are offset by a reduced requirement to purchase international emission permits (because of domestic emissions reductions induced by that tax or ETS), but only up to the point that the cost of domestic emissions reduction equals the world permit price. For New Zealand this cross-over point is reached quite quickly.

The narrow carbon tax provides some additional insight. One model shows a small reduction in the cost of meeting our international obligation, the other shows a small increase. Exempting some industries reduces the overall burden of the tax in that a smaller part of the economy is affected, but exacerbates the selectivity of the remaining distortion. In the NZIER model the former effect dominates, but in the Infometrics model the latter dominates. All of this is implicit in the marginal abatement cost curves.

5.3 Short run results

Table 17 2012 results

Run #	1	2	4	5	1	2	4	5
Description	ETS; no tech or ROW action	Govt pays	As (1) but at $50	Narrow tax with $10 domestic price	ETS; no tech or ROW action	Govt pays	As (1) but at $50	Narrow tax with $10 domestic price
Model	Infometrics	Infometrics	Infometrics	Infometrics	NZIER	NZIER	NZIER	NZIER
Domestic Price	$25	$0	$50	$25	$25	$0	$50	$25
World price	$25	$25	$50	$10	$25	$25	$50	$10
Real GDP	-0.1	0.1	-0.2	0.1	-0.3	0.0	-0.5	-0.1
Real GNDI	-0.2	-0.1	-0.3	-0.1	-0.4	-0.2	-0.8	-0.3
Real Private Consumption	-0.3	-0.2	-0.4	-0.1	-0.5	-0.3	-1.0	-0.4
Employment	-0.2	0.0	-0.4	+0.1	-0.6	0.0	-1.1	-0.2
Real exchange rate	0.1	-0.2	0.2	0.0	0.0	0.4	-0.1	0.3
Emissions	-2.8	0.1	-4.8	-0.2	-1.6	0.0	-3.0	-0.4

Notes: (1) All results %change from BAU unless otherwise stated

Source: Infometrics, NZIER

Table 17 shows the modelling results for various forms of carbon pricing (either an ETS or a narrow carbon tax) and a government pays scenario. Under the reference short run scenario (1) the impact of the ETS ranges from -0.2% of RGNDI at low prices of carbon rising to -0.8% at higher prices of carbon. Employment results vary between -0.2% to -1.1%. Households are impacted under the ETS, with real private consumption declining by 0.3% rising to a loss of 1.0% at higher carbon prices.

A narrow carbon tax on the energy and transport sectors alone, at a domestic carbon price of $10 (compared to a world price of $25), generates a small welfare improvement relative to the proposed ETS of 0.1% of RNGDI. In the short term, the adjustment costs are relatively high due to our assumptions about fixed capital and sticky real wages, so a lower domestic price on carbon can ease the adjustment burden (at the expense of lower emissions reductions).

Another option for meeting our international liability is simply for the government to purchase emissions units in the international market, funded through general taxation (2). NZIER's modelling of this option indicates that the welfare loss is slightly smaller relative to a low priced narrow tax or an ETS. Infometrics' modelling suggests that the welfare loss of the government pays option is on par with a low priced narrow scheme and lower than the welfare loss from ETS.

These short run results suggest that there is little economy wide difference between the government paying for New Zealand's liability from general taxation or introducing an ETS or a narrow carbon tax.

The one exception to this conclusion might be if the government's carbon permit purchasing options are less expensive than those of the private sector, which could then make the government purchasing all emissions units the least cost option for meeting our international obligations. In practice, however, there may be an opportunity for the private sector to work with the government sector to purchase international emission units at the best possible price.

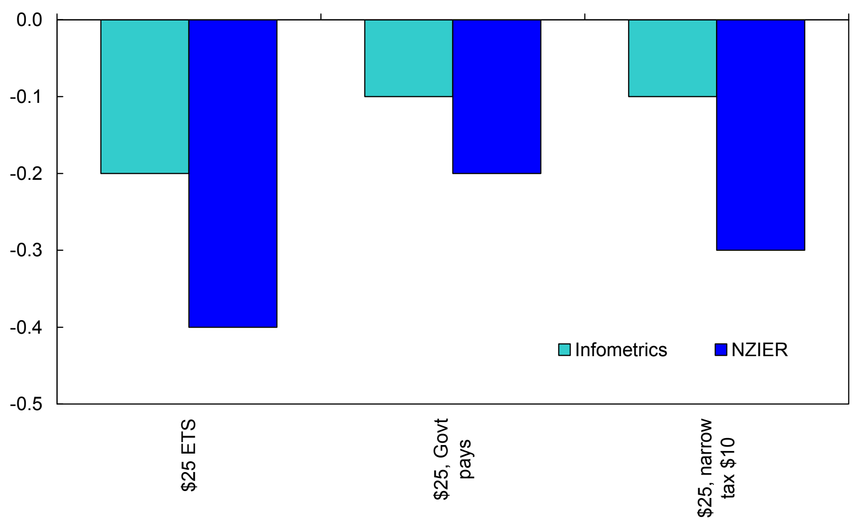
6. Conclusions and recommendations

As shown in Figure 1, our modelling shows that in the short term, which is characterised by less price flexibility in factor markets, a low carbon price, and no major technological advances, the least cost way of meeting our international liability is through government purchasing permits funded by an increase in general taxation (if benefits of avoiding deforestation are not especially significant).[16] This approach, however, does not introduce a price signal into the economy. As a result, firms face little incentive to change their production techniques or to invest in emissions-reducing technology.

If a price is to be introduced into the New Zealand economy, a narrow carbon pricing scheme – whether tax or cap and trade – is marginally less costly than a broad based tax or trading scheme with free allocation (the ETS) in the short run.

Figure 6 Short run modelling results

% change in real GNDI



Source: NZIER and Infometrics

However, note the scale on the chart: **there is little difference** – at an economy wide level – between the welfare effects of the government paying, a narrow

[16] Note that potential benefits from avoiding deforestation can be captured under either a tax or an ETS. If these are significant, then this may tip the balance towards some action in the short term.

tax/trading scheme tax and the ETS with free allocation as proposed (putting aside transaction costs differences) when the world price is low.

On the assumption that a carbon price will be desired in the longer term to be more consistent with the actions of other countries, the government pays scenario is unlikely to be a realistic policy option, unless the government's carbon permit purchasing options are significantly less expensive than that of the private sector.

Accordingly the least cost option for meeting New Zealand's obligation during the first Commitment Period, consistent with optimal long term policy, is a narrow carbon tax or narrow trading scheme.[17]

The 2012 welfare impact of a narrow pricing scheme with a low domestic price is in the range -0.1% to -0.3% of Gross National Disposable Income (GNDI). The welfare impacts of the ETS as previously proposed range from -0.2% of GNDI at low prices of carbon rising to -0.8% at higher prices of carbon, when compared to a Business as Usual (BAU) scenario where there is no New Zealand commitment to an international agreement.[18] The BAU is in fact a rather artificial scenario if viewed from the perspective that New Zealand has signed up to Kyoto and therefore must meet its obligations. New Zealand does not have the BAU option of ignoring Kyoto. Thus the costs we report are the costs of having signed up to Kyoto and the government paying or using an ETS or a tax to meet these obligations.

In the longer term to 2025, we must consider more explicitly the actions of the rest of the world and the degree of technological improvements available to New Zealand firms.[19] These have important impacts on the economy wide cost of abatement. Our modelling shows that **if the rest of the world takes steps to price carbon, and technological change is induced by this pricing, then a broad-based domestic carbon pricing scheme is the least cost way to meet New Zealand's international obligations**. Without action by the rest of the world or technological change, the least cost option can include the free allocation of permits and exemptions for some industries and/or gases.

As the carbon price rises past a certain level, the models show that some form of pricing scheme becomes lower cost than the government pays, even when no action is assumed by the rest of the world and there is no technological change. The point at which a carbon price becomes preferable differs between the two models. At $25/tonne, Infometrics' model ranks a carbon price equal to a government pays

[17] Potentially including measures to avoid deforestation risks.

[18] When interpreting these results, it is important to note that a negative value means that the measure (GNDI, employment, etc) is lower than it would have been otherwise in the absence of any climate change mitigation policy. This is not the same as saying that welfare will be lower than it is now. In all scenarios we still expect the level of welfare or economic activity to increase, but at a slower rate than projected in the business as usual (BAU) scenario.

[19] In our modelling framework, the actions of the rest of the world are modelled as binary choices – they either occur or the don't, but in reality will occur along a continuum between no action and full action. Similarly, technology improvements are modelled by some discrete examples, but in reality technology is a function of price and time – improvements are more likely to be available in the longer run than in the short run.

scenario while the NZIER model slightly favours the latter. At higher prices, both models show that introducing a carbon price is preferable to a government pays scenario.

The key long run modelling results are as follows:

1. **The actions of the rest of the world are important**: If New Zealand takes unilateral action on comprehensively pricing carbon and the rest of the world does not, New Zealand's national economic welfare (RGNDI) is around 0.3% to 0.6% lower than under a scenario where the world does price carbon on all commodities.[20] In reality we can expect an outcome between these two extremes. The impacts on New Zealand reflect its unique, export-centric emissions profile, and highlights why New Zealand should continue to push for global agreements on carbon pricing as a policy priority.

2. **Free allocation can reduce welfare losses particularly when there is only limited action by the rest of the world and there are few abatement technology options available to industry**: Until there is clearer evidence about the actions of the rest of the world and the nature of technological improvements, our modelling shows that there is value in designing any pricing scheme with some flexibility to prevent significant leakage or damage to key industries. Note that free allocation does not mean that there is no incentive to reduce emissions. There is still an opportunity cost of holding the permit; if actions to reduce emissions are less costly than the value of the permit, then reducing emissions makes good economic sense.

   Our modelling suggests that New Zealand will continue to meet any future international obligation primarily by purchasing international emission units rather than by domestic emissions reductions. This occurs because domestic abatement opportunities are limited and costly, and are often associated with output contractions. These contractions can have negative flow-on effects across the rest of the economy. As a result, in a general equilibrium framework, it can be more expensive (economy wide) to abate domestically than to purchase emissions units offshore. That is, the negative effects of less foreign exchange earned by export industries would outweigh the positive effects of more domestic abatement induced by carbon charge. In such situations, a pure price instrument may not be the least cost method of meeting New Zealand's international obligation unless accompanied by the free allocation of emission rights to internationally exposed industries (as a production subsidy to account for a loss of international competitiveness). Over time, we would expect the case for free allocation to diminish as other countries take action and technology improvements become available.

3. **Free allocation for stranded assets is more costly than production-linked free allocation**: If free allocation is based on a lump sum payment to

[20] This provides some scale around the costs of the loss of competitiveness that entering a Kyoto style agreement imposes on the New Zealand economy.

compensate firms for stranded assets, the welfare loss is greater than under a production subsidy approach. This is primarily because these lump sum subsidies are not used to offset the price of carbon, but are instead returned to business owners, many of whom reside overseas. This reduces our preferred measure of national economic welfare (RGNDI), underlining the need to be clear about what free allocation is intended to address – compensation for lower asset values, exposure to international competition (and carbon leakage), or some concept of minimum regret.

4. **The higher the world carbon price, the greater the cost to the New Zealand economy**: An increase in the price of carbon from $25 to $100 (per tonne of CO_2) raises the welfare cost from around 1.0% of RGNDI to 3.0% to 3.5%.

5. **The New Zealand economy will continue to grow under a carbon pricing scheme**, albeit at a slightly lower rate. In the absence of any policy change, we estimate RGNDI will grow from around $38,500 per capita in 2009 to $56,000 per capita in 2025. Under a carbon pricing scheme with a world price of $100, this will fall by between $1,700 and $2,000 by 2025.

6. **New abatement technologies improve the relative welfare impact of price instruments**. Such technologies result in higher levels of emissions abatement at lower costs to the economy. When the abatement cost is below the world price of carbon, a pricing scheme is the least cost option for meeting our obligation. In approximate terms, every 2% fall in total emissions from new abatement technologies reduces the loss in economic welfare by around 0.1%.

   The development of abatement technologies can be positively influenced by a price on carbon.[21] We do not capture this explicitly within our models. However while a price on carbon increases the pay-off to abatement technology, it does not guarantee 'silver bullet' solutions.

7. **Changes in the size of the capital stock have significant economic effects**: The modelling assumption regarding whether the capital stock is able to vary in the long run has a significant effect on the results. If the total capital stock in the economy is invariant to the introduction of a carbon price, the welfare losses are lower: At a carbon price of $25, the welfare loss is reduced by 0.5%. At $100 the effect is around 2.0%.

8. **Differential pricing has minimal impacts**: Under a narrow tax our models show no measurable welfare impact from the carbon price in New Zealand being either $10 or $40 when the world price is $25. This reflects the fact that at low prices of carbon New Zealand meets the vast majority of its obligations by purchasing offshore. If the world price is higher, differential pricing may have more significant negative welfare impacts.

[21] It is more likely that abatement technologies are developed over a longer rather than a shorter time-frame.

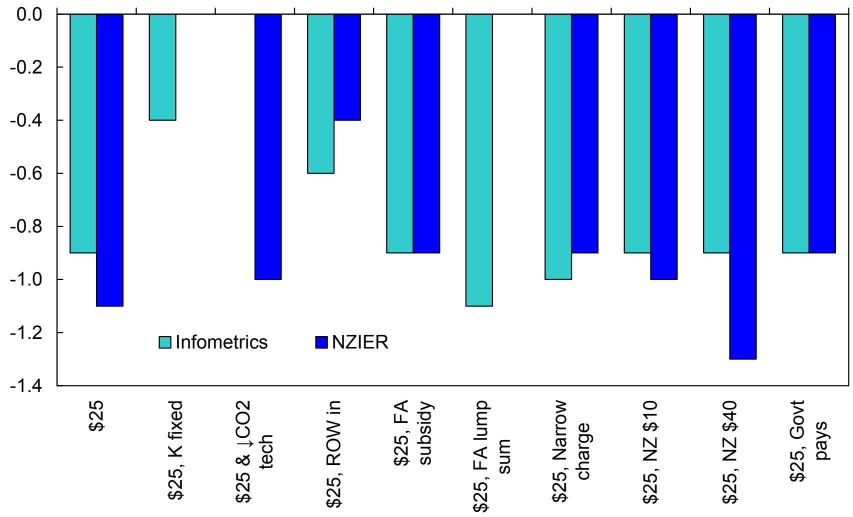
9. In rough terms the size of our Kyoto obligation means that in 2012 New Zealand has to buy emission permits to cover about 9 Mt of CO_2. At $25/tonne this implies $225 million of payments offshore every year of CP1, or $1,125 million over the five years of CP1. We can think of this as the size of the 'shock' to the economy. To put this into some sort of perspective, the reduction of import tariffs from their 1986 level would, if it took place over CP1, imply an economic shock of about $4,400 million in current prices.

The changes in RGNDI for the long term scenarios are illustrated in the two graphs below. The first relates to a carbon price of $25/tonne. It shows the importance of action by the rest of the world in lowering the cost to New Zealand of meeting any international emissions obligation. The graph also shows the relative closeness of the two sets of results for most scenarios.

The second graph clearly demonstrates the effect of a higher carbon price and the potential contribution from new abatement technologies that might be encouraged by a high carbon price.

Figure 7 Long run modelling results: $25 price

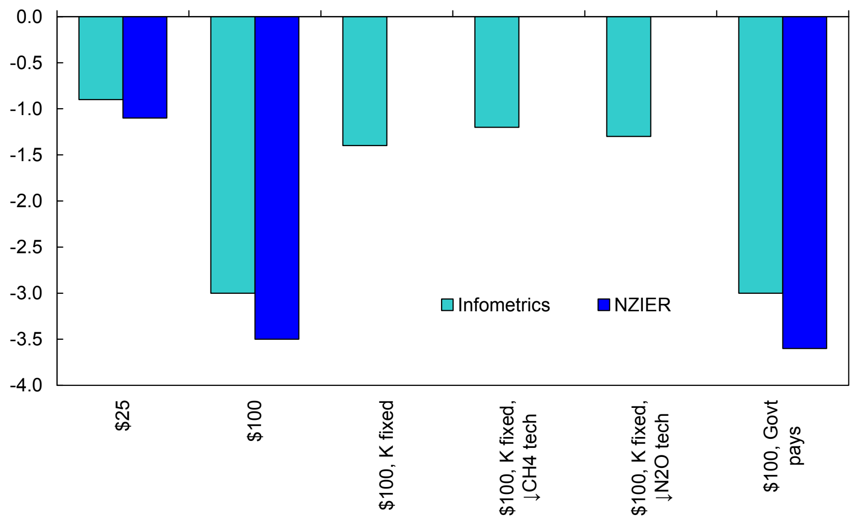
% change in real GNDI



Source: NZIER and Infometrics

Figure 8 Long run modelling results: $100 price

% change in real GNDI



Source: NZIER and Infometrics

Conclusions and recommendations

1. The New Zealand economy will continue to grow under all of the scenarios that we have modelled. In the absence of any policy change, we estimate that income per capita (as measured by RGNDI) will grow from around $38,500 in 2009 to $56,000 in 2025. The introduction of a carbon price will not significantly affect New Zealand's potential *growth* rate.

2. However, there is a cost to meeting our international commitments. Under a carbon pricing scheme with a world price of $100, per capita income could fall by up to $2,000 by 2025. The magnitude of the economy wide costs of meeting our international obligations are not determined solely by domestic policy settings. The actions of the rest of the world and the level of the world carbon price have important ramifications for the cost to the New Zealand economy.

3. In the short run, there is relatively little difference, at the macroeconomic level, between the government funding our Kyoto liability through general taxation, an ETS with free allocation and a narrow pricing scheme that covers just the energy and transport sectors.

4. In our view, while the government pays scenario can be the cheapest option, it has two key drawbacks. First, it does not introduce a price signal for carbon into the New Zealand economy. This means that firms face little incentive to change their production patterns, or to invest in emissions-reducing R&D. Firms need clear and consistent policy signals around the pricing of carbon so that they can make efficient long term investment decisions.[22] Second, it is an untenable political economy approach to emissions reduction in the longer term.[23] The global trend is clearly moving towards the gradual introduction of carbon pricing, albeit slowly and in varying forms.[24] Our understanding of the international climate change negotiations is that New Zealand would lose credibility if it was to shy away from carbon pricing. This is unlikely to benefit the country in the longer term – being 'outside the tent' is not a place that New Zealand can afford to be. Given our unique emissions profile, New Zealand needs to be at the table when post-2012 negotiations take place to ensure that our voice is heard and that the outcome is equitable. We cannot realistically do so if we do not have a commitment to a domestic carbon price.

5. We therefore recommend that the introduction of a carbon price is warranted. In the short run, a narrow based carbon pricing scheme (whether tax or trading scheme) at a low domestic price can provide this signal at a slightly lower economy wide cost than an all-industries, all-gases ETS with free allocation.

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[22] Certainty could also be created through a commitment to have no carbon pricing in the foreseeable future, although we do not believe this is realistic from an international relations perspective.

[23] This is not a conclusion from our modelling results. It is a judgement based on our understanding of the international climate change negotiations.

[24] Putting a price signal in place gives the economy more time to transition to a lower carbon footprint.

6. The ETS, however, provides a price signal across the entire economy. And in the longer run, if the rest of the world takes action and technological improvements take place, our modelling shows that a broad based full price signal with no free allocation or exemptions is the least-cost way of meeting our post-2012 obligations.

7. With this long term scenario in mind, there would appear to be advantages, from a policy signalling and investment certainty perspective, of the government introducing an ETS in the short run as well. However, there are two key provisos related to competitiveness at risk and measurement costs, as explained in points 8 and 9.

8. Competitiveness at risk issues need to be considered. Until there is clearer evidence about the actions of the rest of the world and the nature of technological improvements, our modelling shows that there is value in designing any pricing scheme with some flexibility to prevent significant leakage or damage to key industries. Free allocation linked to output can be a cost-reducing mechanism of dealing with high costs of abatement and a lack of action by other countries (leakage and competitiveness at risk issues). Free allocation as compensation for stranded assets does not have this effect, though may be justified on equity grounds.[25]

9. If the aim of climate change mitigation policies is to change producers' behaviour, it is vital to be able to measure emissions in a cost effective manner. If the transaction costs of measuring emissions outweigh the benefits of emissions reduction, the policy may not be net welfare enhancing. Therefore the transaction costs of implementing an all-sectors all-gases ETS need to be evaluated. It may be advisable to exempt sectors such as agriculture where measurement costs are high relative to the benefit that would be gained from that sector's inclusion. Our modelling suggests that, in the short term, such exemptions do not reduce economy wide welfare.

10. On balance, **our recommendation in the short run is to introduce an ETS with free allocation to competitiveness-at-risk sectors, with agriculture excluded if measurement of its emissions is prohibitively expensive. Free allocation should be output-linked and phased out as our competitors adopt carbon pricing. If agriculture is initially excluded it should be transitioned into the ETS, with free allocation if required, as measurement becomes economic.**

[25] Modelling the likely change in economy wide costs from different types of free allocation is difficult until we are clear on their intent. Accordingly we encourage policy makes to be clear about what free allocation is intended to achieve and to design it accordingly.

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Appendix A Summary of modelling simulations

Table 18 Summary of modelling results – Infometrics

Run #	1	2	4	5	8	8a	9	10	11	12a	14	14a	15	16	17	18	19	20	21	22
Timeframe	Short run	Short run	Short run	Short run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run
Topic	Reference	Govt Pays	Price Sensitivity	Narrow tax with price differential	Reference	Reference	Assistance	Assistance	ROW	Technology CH4/NO2	Price Sensitivity	Price Sensitivity	Reference - narrow tax	Low domestic price: narrow coverage	High domestic price:narrow coverage	Low domestic price: full coverage	High domestic price: full coverage	Narrow tax - all energy	Govt pays	Govt pays $100
World price	$25	$25	$50	$25	$25	$25	$25	$25	$25	$100	$100	$100	$25	$25	$25	$25	$25	$25	$25	$100
Domestic price	$25	$0	$50	$10	$25	$25	$25	$25	$25	$100	$100	$100	$25	$10	$40	$10	$40	$25	$0	$0
Coverage	Ag and Waste excl	N/A	Ag and Waste excl	Energy and transport	Full	Full	Full	Full	Full	Full	Full	Full	Elec Prod and trans	Elec Prod and trans	Elec Prod and trans	Full coverage	Full coverage	Energy and transport	N/A	N/A
Free allocation	Yes	N/A	Yes	N/A	No	No	90% Production Subsidy	90% Lump Sum	No	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ROW	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No	No
Technology	No	No	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Forestry	Exog	Exog	Exog	Exog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog
Capital stock assumptions	Fixed Capital	Fixed Capital	Fixed Capital	Fixed Capital	Fixed rate of return	Fixed Capital	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed Capital	Fixed rate of return	Fixed Capital	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return
Real GDP	-0.1	0.1	-0.2	0.1	-0.6	0.0	-0.5	-0.7	-0.4	-0.2/-0.1	-2.1	-0.1	-0.4	-0.4	-0.5	-0.4	-0.8	-0.5	-0.2	-1.0
Real GNDI	-0.2	-0.1	-0.3	-0.1	-0.9	-0.4	-0.9	-1.1	-0.6	-1.2/-1.3	-3.0	-1.4	-1.0	-1.0	-1.0	-0.9	-0.9	-1.0	-0.9	-3.7
Real Private Consumption	-0.3	-0.2	-0.4	-0.1	-1.1	-0.7	-1.4	-1.8	-0.7	-2/-2.1	-3.7	-2.2	-1.2	-1.3	-1.2	-1.1	-1.1	-1.3	-1.1	-4.6
Real wages	-0.2	0.0	-0.4	0.1	-1.5	-0.7	-1.2	-1.5	-1.0	-2.6/-2.6	-5.3	-2.7	-0.8	-0.6	-1.0	-0.8	-2.1	-0.9	-0.1	-1.2
Real exchange rate	0.1	-0.2	0.2	0.0	0.0	-0.4	0.0	-0.1	0.4	-1.1/-1.2	0.0	-1.3	-0.2	-0.4	-0.1	-0.3	0.2	-0.2	-0.4	-2.0
Emissions	-2.8	0.1	-4.8	-0.2	-4.3	-4.0	-4.0	-4.4	-3.0	-17.6/-15.8	-14.4	-13.2	-1.6	-0.7	-2.5	-1.8	-6.7	-2.4	0.1	0.0

Source: Infometrics

Table 19 Summary of modelling results – NZIER

Run #	1	2	4	5	8	9	11	12	14	15	16	17	18	19	20	21	22
Timeframe	Short run	Short run	Short run	Short run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run	Long run
Topic	Reference	Govt pays	Price Sensitivity	Narrow tax with price differential	Reference	Assistance	ROW	Tech	Price Sensitivity	Reference	Low domestic price: narrow coverage	High domestic price:narrow coverage	Low domestic price: full coverage	High domestic price: full coverage	Narrow tax - all energy	Govt pays	Govt pays $100
World price	$25	$25	$50	$25	$25	$25	$25	$25	$100	$25	$25	$25	$25	$25	$25	$25	$100
Domestic price	$25	$0	$50	$10	$25	$25	$25	$25	$100	$25	$10	$40	$10	$40	$25	$0	$0
Coverage	Ag and Waste excl	N/A	Ag and Waste excl	Energy and transport	Full	Full	Full	Full	Full	Elec Prod and trans	Elec Prod and trans	Elec Prod and trans	Full coverage	Full coverage	Energy and transport	N/A	N/A
Free allocation	Yes	N/A	Yes	N/A	No	90% Production Subsidy	No	No	No	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
ROW	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No	No
Technology	No	No	No	No	No	No	No	Yes	No	No	No	No	No	No	No	No	No
Forestry	Exog	Exog	Exog	Exog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog	Endog
Capital stock assumptions	Fixed Capital	Fixed Capital	Fixed Capital	Fixed Capital	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return	Fixed rate of return
Real GDP	-0.3	0.0	-0.5	-0.1	-0.7	-0.3	-0.3	-0.6	-2.7	-0.3	-0.2	-0.3	-0.4	-1.0	-0.3	-0.2	-0.8
Real GNDI	-0.4	-0.2	-0.8	-0.3	-1.1	-0.9	-0.5	-1.0	-3.5	-0.9	-0.9	-0.9	-1.0	-1.3	-0.9	-0.9	-3.6
Real Private Consumption	-0.5	-0.3	-1.0	-0.4	-1.2	-1.0	-0.5	-1.1	-3.7	-1.0	-1.0	-1.0	-1.1	-1.4	-1.0	-1.0	-4.1
Real wages	-0.6	0.0	-1.1	-0.2	-2.6	-1.4	-1.8	-2.5	-9.7	-1.2	-0.8	-1.6	-1.4	-4.0	-1.4	-0.5	-2.2
Real exchange rate	0.0	0.4	-0.1	0.3	1.0	0.3	0.1	0.9	2.9	0.4	0.6	0.2	0.8	1.3	0.4	0.7	2.7
Emissions	-1.6	0.0	-3.0	-0.4	-5.5	-1.9	-3.0	-8.3	-21.3	-1.6	-0.5	-2.6	-2.0	-8.5	-1.9	0.2	0.9

Source: NZIER

Appendix B Terms of Reference

The Government has established a special select committee to review the Emissions Trading Scheme and related matters as provided for in the National-Act Confidence and Supply agreement. The terms of reference of the select committee require:

> *"a high quality, quantified, regulatory impact analysis to be produced to identify the net benefits or costs to New Zealand of any policy action, including international relations and commercial benefits and costs"*

Desired Output

To provide the select committee with sound policy advice, the Government requires a high quality regulatory impact analysis of policies aimed at addressing climate change.

The regulatory impact analysis shall, as outlined in the Special Select Committee Terms of Reference, provide a fully quantified economic cost benefit analysis that identifies the net benefits or costs of the following options:

- The least-cost option for meeting any Kyoto liability
- The proposed Emissions Trading Scheme
- A revenue-neutral tax on carbon or carbon equivalents, coupled with an equivalent subsidy for carbon links, or a tax on energy

Work Allocation

The fully quantified economic cost benefit analysis will be contracted out to two separate consultancy firms who will form a joint venture to complete the work.

Timing

The regulatory impact analysis is due with the select committee by 9.00 am, 13 April. A draft must be supplied to the Ministry for the Environment no later than 5.00 pm, 3 April. Comments on the draft will be provided to the contractor by midday, 8 April.

The contractor will report weekly on progress to the Ministry for the Environment.