CLIMATE CHANGE WORKING PAPER

Assessment of Economic Modelling

This document provides additional information on the main economic modelling work that has been carried out to date. It supports the consultation on climate change policy options. This is an officials' working paper and is not government policy.

New Zealand Climate Change Programme

Te Hōtaka Rerekētanga Āhuarangi o Aotearoa

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Options for managing New Zealand's greenhouse gas emissions are discussed in the working papers: *Domestic Emissions Trading, The Use of Projects, Negotiated Greenhouse Agreements, and Levies to Reduce Greenhouse Gases,* and *Emission Charges and Land Use and Forest (Sinks) Sector.* Other working papers that are also available are: *Legislation to Ratify the Kyoto Protocol* and *Maori Issues.*

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Introduction

The Government's climate change consultation document: *Kyoto Protocol: Ensuring Our Future* gives a brief outline of possible economic effects of ratifying the Kyoto Protocol. The outline is based on the findings in two reports:

- *Economic outcomes of the Kyoto Protocol for New Zealand*, prepared by the Australian Bureau of Agricultural and Resource Economics (ABARE), ("the ABARE report") and

- *Assessment of the likely impacts on selected sectors of a domestic emissions trading regime,* prepared by PA Consulting ("the PA Report").

This working paper provides background to the development of those economic analyses, and an assessment of their findings. It should be read in conjunction with those reports. The purpose of this paper is to outline the background to the reports, and make clear the advantages and limitations of the analysis techniques used in them in order to assist understanding of what the findings represent.

Background

As part of New Zealand's ratification decision, it is important that as a nation we have some understanding of what economic outcomes we could expect from ratifying and bringing into force the Kyoto Protocol. In January 2001, a review was undertaken of what economic analyses were already held, and what further information would be needed.

Information already held

Since the early 1990s, numerous studies have been carried out into possible economic outcomes of managing greenhouse gas emissions. Earlier studies focused on the effects of meeting New Zealand's voluntary target under the UN Framework Convention on Climate Change, and on possible outcomes of the Kyoto Protocol negotiating round.

In March 2000, two years after the initial development of the Kyoto Protocol, a major economic modelling study of possible effects for New Zealand was completed. That study was carried out by Warwick McKibbin and David Pearce at the Centre for International Economics, using the G-Cubed model[1]. They examined the possible effects of meeting New Zealand's obligations under the Kyoto Protocol by applying an emissions charge or emissions trading system to carbon dioxide emissions. The results provided information on the possible headline economic effects (such as national income, employment, and import and export levels), the path of effects over time, and a possible pattern of changes in industry outputs.

However, while the G-Cubed model could examine management of carbon dioxide emissions, it could not account for other greenhouse gases or for sinks (forested areas that absorb greenhouse gases). Further, it provided industry information for 12 industry sectors only. These were mainly emissions-intensive sectors, but this meant that most of the economy was included in large, aggregated general sectors. Finally, the model gave only one measure for greenhouse gas management – a price instrument.

Requirements for further information

To work out the effects on New Zealand of ratifying and bringing into force the Kyoto Protocol, it would be necessary to know (among other things):

- the policies to be used in New Zealand's domestic greenhouse gas management programme
- the policies that other developed countries would put into place as Parties to the Protocol
- the policies that would be put in place by developed countries that did not ratify the Protocol (such as the US), but remained Parties to the Framework Convention and
- the actions of developing countries (for example, what decisions they would make on capital investment, including the role of the Clean Development Mechanism[2]).

[1] G-Cubed is a multi-country economic model designed to identify the international economic effects of greenhouse gas reduction policies. It is a computable general equilibrium model, a similar type of model to that used by ABARE.

[2] A mechanism in the Kyoto Protocol by which developed nations can gain extra emission units by helping developing nations to reduce their greenhouse gas emissions.

These matters are not yet known with certainty. New Zealand's domestic policies are not yet decided and, at the time of writing, the actual rules of the Kyoto Protocol were not quite finalised (although the October 2001 writing was based on knowledge of the general political agreement from Bonn in July 2001, and clarity on the US position, which was not the case in January 2001 when the initial review was carried out).

Given these constraints, the process of gathering information needs a somewhat circular approach. New Zealand's domestic policies need to be known in order to work out economic effects for New Zealand under the Protocol; but at the same time, an idea is needed of the possible economic effects of the policies in order to make those domestic policy choices.

The chosen method was to carry out exploratory modelling of a range of different scenarios. Some examined different domestic policies, some the effects of different rules under the Protocol, and others the sensitivity of outcomes to different levels of international participation. The exploratory modelling could give an idea of which sets of policy options might result in greater or lesser economic impacts for New Zealand than others.

What to model?

In 1999, the most recent year for which national emissions have been reported, New Zealand's greenhouse gas emissions were mostly methane (44%), carbon dioxide (40%) and nitrous oxide (16%). The bulk of carbon dioxide is produced from energy use (commerce and industry, thermal electricity, transport), while the bulk of methane and nitrous oxide is produced from livestock farming. Although methane and nitrous oxide currently make up the majority of emissions, carbon dioxide emissions are growing at a much faster rate, mainly because of growth in transport and thermal electricity generation. Against this, New Zealand has a large number of post-1990 forests that are absorbing carbon dioxide, and will provide New Zealand with potentially tradable sink credits under the Kyoto Protocol.

This has meant that further work to identify economic outcomes would be increasingly helpful the more it could account for:

- possible measures to manage agricultural methane and nitrous oxide emissions
- possible measures to manage carbon dioxide emissions
- the possibility of sink credits being available for international trade
- international effects resulting from other developed and developing countries' participation (or not) in the Kyoto Protocol.

While these points are easy to write down, the complexity of including the options into an economic analysis cannot be overstated. The range of possible domestic and overseas policy responses is very wide. The Kyoto Protocol's requirements will change energy prices, and may change the costs of primary production, at a global level. As well as affecting international trade and investment patterns, those changes will have effects that flow through all of the interconnections within the New Zealand economy.

What economic indicators to look at?

There are a multitude of different indicators of the state of an economy, and of the effects of a new policy in altering the economy. These include measures of the performance of the economy as a whole, such as gross national income, gross domestic product, employment, inflation, exports, imports, the balance of payments and the exchange rate.

There are also sectoral economic measures that apply to specific industry groupings, such as production levels (output), sectoral employment, investment and supply prices. These can indicate the performance of each industry sector underneath the overall national indicators.

Finally, there is the question of who is affected. There are indicators for assessing outcomes for different geographic regions, household types, income levels or ethnic groups.

Choice of method

The range of possible policy measures that could be adopted both in New Zealand and overseas under the Kyoto Protocol, and the complexities of the interactions of those possible measures, means that there is no perfect tool or method for analysing their effects.

Because the analysis involves policies whose effects could potentially spread widely throughout the New Zealand economy, and also affect international trade flows and overseas economies, a "computable general equilibrium" (CGE) model was considered the best tool available for this type of analysis. The results from such modelling would be constrained by the limitations of CGE models[3], but such models were considered to be clearly superior to other available analysis techniques because they can account for whole-of-economy interactions as well as international responses.

It was decided to carry out an exploratory analysis using a CGE model that could combine greenhouse gas emissions, New Zealand industry sector responses and international trade patterns.

For this exploratory analysis, the model chosen was the Global Trade and Environment Model (GTEM) operated by the Australian Bureau of Agricultural and Resource Economics (ABARE). The advantages of the GTEM for New Zealand are that the model:

- is internationally recognised and has been reviewed in international forums
- allows for management of methane, nitrous oxide and carbon dioxide
- includes a basic representation of forest sink activities
- provides results for 33 industry sectors, with a focus on primary production
- allows both domestic and international economic adjustments to take place, so allowing for the flow-on effects between different markets and different sectors of the economy.

[3] Repetto and Austin (1997) review the use of CGE models in climate change economic modelling; Pezzey and Lambie (2001) compare in detail four Australian models that have been used in climate change economic modelling, including G-Cubed and GTEM.

This was complemented by a qualitative study by PA Consulting of the possible effects on seven broad industry groupings within New Zealand of their inclusion in a domestic emissions trading scheme. Again, the aim of the analysis was exploratory, to identify the possible effects of an emissions trading scheme and so help the design of policy measures, rather than to represent the effects of policy decisions already made.

Important information for readers

The results in the ABARE report and, where relevant, the PA Report need to be read in the following context:

- The scenarios examined by ABARE and PA are exploratory.
- The ABARE model is the best quantitative tool for this type of broad-level analysis of the economy. However, the results show only what might happen, given the assumptions on which the model is based and the techniques that have been used.
- The ABARE modelling is based on one instrument, an emissions price applying to all greenhouse gas emissions in particular sectors.
- The results do not take into account policies that could offset any adverse effects of applying an emissions price.
- The model also does not allow for the effects of other policies that will assist New Zealand to meet its Kyoto obligations, such as the National Energy Efficiency and Conservation Strategy, or other incentives for the reduction of emissions.
- It does not account for changes in technology, the development of new industries, or the full economic effects of New Zealand's forest sinks (forested areas that absorb and store greenhouse gases).
- The actual economic effects of meeting the Kyoto Protocol depend on decisions that are yet to be taken.
- This modelling will help in identifying which policy options will best assist New Zealand in meeting its Kyoto obligations.

The ABARE Report

ABARE's GTEM model was used first to examine 13 scenarios, without knowing how the Protocol's flexible mechanisms would operate. In most of the scenarios it was assumed that the US would take part in the Kyoto Protocol. As the Protocol's rules were finalised, many of those initial scenarios became redundant. It also became clearer that the US was not immediately about to re-engage with the Protocol, even though it is entirely possible that it will do so before 2008.

Based on those developments, a further six scenarios were examined on the basis of US non-participation, and it is those scenario results that are discussed in this document.

In all six scenarios, it was assumed that the US would not ratify the Protocol. The six scenarios comprised three different treatments of agricultural methane and nitrous oxide emissions by the countries listed in Annex B of the Protocol[4]. Each of those was examined with Australia ratifying, and not ratifying, the Protocol.

The scenarios are set out in Table 1. Other assumptions included:

- no use of the Clean Development Mechanism or Joint Implementation and
- without US participation, Russia dominating and supplying the international emissions market in a way that maximised Russian revenue.

Sinks under Article 3.3 of the Kyoto Protocol were included across all Annex B countries, but not those under Article 3.4.

Table 1: Scenarios modelled by ABARE

Scenarios	**Ratification status**		**Annex B coverage of agricultural methane and nitrous oxide emissions**:		
Simulation	US Ratifies	Australia ratifies	All Annex B	NZ-only	None
1	**x**	✓	✓		
2	**x**	✓		✓	
3	**x**	✓			✓
4	**x**	**x**	✓		
5	**x**	**x**		✓	
6	**x**	**x**			✓

An overview of the main findings from these scenarios is given further below.

The PA Report

The work commissioned from PA Consulting in April 2001 was intended to complement the ABARE study by investigating how characteristics of selected sectors would affect their response to the introduction of an emissions trading system.

[4] The countries listed in Annex B of the Kyoto Protocol are the countries with an emissions target in the first commitment period; in loose terms, the developed countries.

The purpose of using emissions trading is to ensure that the responsibility for managing greenhouse gas emissions lies with those who create those emissions in the first place. It requires selected entities (known as "points of obligation") to ensure that they hold enough emission units to cover their emissions, either by abating their own emissions or through purchasing other people's surplus emission units. (This is referred to here as "placing obligations on" the sector in question.)

PA Consulting was asked to consider the likely economic impacts if emissions trading, or measures that provided comparable incentives to emissions trading, were applied to each of the selected sectors. In order to identify each sector's relative level of sensitivity to such a system, the study applied the system as uniformly as possible across sectors, without any concessions to particular industries.

It was assumed that firms would have to buy their emission units through competitive tender, that these units would be internationally tradable, and that the value of emission units in 2008 would be NZ$20 per tonne of CO_2-equivalent. This assumed price is close to that obtained from G-Cubed modelling, but is considerably lower than the price subsequently generated by GTEM.

The study focused on the activities considered potentially the most sensitive to the effects of emissions trading:

- coal, gas and geothermal energy – encompassing energy suppliers (including electricity generators) and users
- oil-based fuel suppliers and transport fuel users
- industries that give rise to CO_2 emissions from non-combustion processes, such as the calcination of lime in cement manufacture, reduction of iron-sand in steel making, and carbon anode wastage in aluminium smelting
- industrial processes that cause non-CO_2 emissions, such as those from synthetic substances used in insulation, refrigeration and switch-gear
- solid waste disposal and wastewater treatment
- agricultural emissions, particularly from pastoral animals
- forestry, including both obligations on deforestation and sink credits under the Kyoto Protocol for afforestation.

The report describes the expected impact of the greenhouse emissions obligations on the structure, conduct and performance of the sectors examined. The report was completed in late July 2001.

Limitations and advantages of the analysis techniques

This section sets out a series of points that readers should bear in mind when considering the ABARE and PA reports, and also describes the limitations and advantages of the analytical techniques used in each report.

Limitations of the ABARE modelling

The model works by applying price changes, so it examines only policies that involve putting a price on greenhouse emissions. The model does not examine policies such as energy efficiency measures or other non-price measures, or market-based measures such as projects or levies that could be put in place in different sectors of the

economy. It does not account for other domestic policy measures currently being developed at a national level that could also affect emissions, such as:

- the National Energy Efficiency and Conservation Strategy
- the New Zealand Transport Strategy
- the Waste Minimisation and Management Strategy

While the model identifies possible direct or first-round effects of price measures under different scenarios, it does not account for possible offsetting policies, such as the effects of allocating New Zealand's emission units by means other than auctioning, or using emissions charges or auction revenue to reduce existing taxes. Such policies could have a large bearing on how the Protocol's effects are concentrated or spread around New Zealand society.

The model is better at looking at longer-term changes than short-term changes, and its outputs are based on past years' spending patterns in the New Zealand economy[5]. This means that the model does not:

- predict future technology changes (it can only adjust what is already known)
- forecast new patterns of industry behaviour[6] (it can only predict the strengthening or weakening of the patterns that already exist)
- give a clear picture of short-term changes that occur as the economy adjusts
- predict "threshold effects"[7]
- include potential economic gains from new business opportunities presented by the Kyoto Protocol.

The model provides no direct information on distributional effects by region, household income level or social grouping. This is because the model assumes a single representative household, thereby averaging out any effects that differ across different types of households.

The GTEM model has been assessed in one study as generating emissions prices that are at the high end of the range of such prices as generated by general equilibrium models (Weyant and Hill, 1999). For example, in the most recent modelling prepared for New Zealand, GTEM generated prices of between NZ$49 and $73 per tonne of carbon dioxide. This contrasts with a price of NZ$18 per tonne of carbon dioxide under the earlier G-Cubed modelling (which assumed US participation in the Protocol). This may overestimate both the cost of emissions and the returns from sink credit sales.

The model assumes perfectly competitive markets. In reality, however, there are costs associated with running a market economy, and adjustments to the structure of the economy require time and resources. The model assumes that these "transaction" and "adjustment" costs are zero.

[5] For this study, GTEM was used with the Global Trade Analysis Program version 4.0e database. This was released in 1998, and at the time was the most recent version available, based on a 1995 input-output table.

[6] The model does allow price-induced substitution of one energy source for another as well as substitution between imported and locally supplied business inputs.

[7] "Threshold effects" refer to the situation where, at some level of emissions price, local companies find that they cannot maintain a scale of production sufficient to cover their costs, or that they are no longer competitive with imports (or against other countries in export markets). In such a case, production from that industry could suddenly fall or stop completely at some emissions price level. However, the model assumes that production falls are relatively smooth and continuous. If there are threshold effects, the negative impacts on sectoral production, GDP and GNI could be greater than suggested by the model.

If the Kyoto Protocol is ratified by New Zealand and subsequently enters into force, then it is possible (depending on domestic policy choices) that greenhouse gas emissions during the commitment period within New Zealand will involve a domestic financial cost. The GTEM model assumes that no one takes account of that cost in their pre-2008 investment decisions, whereas in reality some people would, which would lower the cost of New Zealand's emissions over the commitment period.

Finally, the model's treatment of sink credits is limited. While it links the revenue from sink credit sales to New Zealand's national income, it does not provide for land use changing from agriculture to forestry (or vice versa), nor does it direct the sink credit revenue to the forestry sector or to consumers who own sink credits.

Advantages of the ABARE modelling

The above section describes the limitations of computable general equilibrium models in modelling scenarios where a wide range of policies could be imposed, with complex interactions. As such, it provides a warning that the background to CGE results should be considered along with the results, rather than simply taking the numbers at face value and using them out of context, without considering the limitations. In other words, the numbers produced by this model are *indicative estimates only*.

Despite those limitations, the GTEM results represent the best information available for New Zealand for the given policy scenarios. The model:

- recognises inter-industry relationships, international trade effects, and substitution between different inputs, goods and services
- takes account of a very broad range of socio-economic variables to generate results
- identifies economy-wide patterns of sectoral responses that, if the scenario occurred exactly as modelled, could be indicative of real adjustment patterns in broad terms, (although subject to the limitations described above).

An important advantage of the GTEM model is that it accounts for the effects of important economic variables other than the emissions price. The international trade and exchange rate effects caused by developed countries' implementation of the Kyoto Protocol will be significant for New Zealand's small open economy.

For these reasons, the GTEM modelling is considered likely to provide a better picture of effects on the economy as a whole than other analysis techniques or models.

Annex 1 of this paper sets out examples of the limitations and advantages of the ABARE report.

Limitations and advantages of the PA Analysis

Using the structure-conduct-performance model, in isolation, to assess the effects of policies on industry sectors does not allow for domestic and international economic feedback loops that alter other economic variables apart from the emissions price.

In addition, the PA Report focuses mostly on emitting sectors that are likely to be "points of obligation" for emissions. This means that it gives little information about low-emitting sectors that may increase output due to resource inflows as emissions-intensive sectors take steps to reduce their emissions.

The advantage of such analysis is that it allows a reality-check of the CGE results (which assume perfect markets) against market conditions in New Zealand. These conditions include domestic oligopolies or markets in which there is only a single company, transport conditions (times and distances), infrastructure and processing limitations and imperfect information. The report also examines the waste management sectors, which are not covered by the GTEM model.

Main findings

The ABARE Report

The results presented for each scenario are for the middle year of the commitment period, 2010. The results are shown as a percentage change from a reference (or "business as usual" (BAU)) case, allowing for current growth forecasts and the absence of any policies to manage emissions[8] or to recycle revenues.

Analysis of these scenarios showed the following findings:

- Gross Domestic Product (GDP) consistently fell relative to its "business as usual" level, by between 0.08 and 0.26% (depending on the scenario specifications). This indicates that domestic economic activity declines with domestic emissions abatement.

- Gross National Product (GNP), which is a more complete measure of national income than GDP, as it measures the income available to New Zealanders for spending and saving, consistently rose relative to its "business as usual" level by between 0.05 and 0.52% (depending on the scenario specifications). This indicates that the decline in income from reduced domestic economic activity is more than offset by the gain in income from international sales of sink credits.

- The pattern of changes in industry sector output was broadly consistent across scenarios:
  - most emissions-intensive industries showed percentage reductions in output levels per sector that were much larger than the small percentage falls in GDP
  - most other industries showed zero change or small percentage increases in output relative to their "business as usual" levels. (Note: under the model, where output is decreasing for a sector, it means the sector's resources are moving into relatively more profitable industries.)

[8] This "business as usual" case probably gives year 2010 emission levels that are too high, because the BAU case does not account for emissions reductions that are expected to be achieved under the National Energy Efficiency and Conservation Strategy, which was announced in September 2001.

- Removing the emissions price from agricultural methane and nitrous oxide emissions:
  - reduced the GDP loss and increased the GNP gain in New Zealand if the price were removed in all Annex B countries but
  - increased the GDP loss and reduced the GNP gain in New Zealand if the price were removed in all Annex B countries except New Zealand.

- In the two scenarios where no emissions price was applied to methane and nitrous oxide emissions over Annex B agriculture as a whole, Australia's non-ratification of the Protocol fractionally improved New Zealand's macroeconomic outcomes.

- Real wages fell by 1.3% to 2.4%, and returns on capital by 1.7% to 2.8%, across scenarios. This suggests that (distributionally) the overall gain in national income is driven by a large increase in income to the owners of sink credits.

The PA Report

The PA report suggests emissions trading would have a discernible impact on the coal, gas and geothermal industries, and on the closely associated electricity sector. Prices for coal, gas and electricity would be likely to increase to varying degrees. There would be a technology shift towards more wind and small-scale hydro generation, but no significant reduction in the use of gas for electricity production supplying peak demand. Coal mines of marginal value could close. At $20 per tonne of carbon dioxide, energy price increases would produce only a limited demand-side response for fuel conservation without other conservation measures.

End users of fuels and transport services would face a small increase in prices due to the cost of emissions from refined petroleum products. However, the size of the increase would be within the range of normal price fluctuations in the oil market and would not be large enough to significantly affect people's choices of transport or fuel.

The report suggests that industries that emit CO_2 from non-combustion processes would face varying effects. It suggests that the viability of primary production of steel and aluminium could be put in doubt, but the effects on cement and lime processing would be less severe. An emissions trading system at $20 per tonne of carbon dioxide-equivalent would add little to the cost of products that cause non-CO_2 emissions arising from synthetic gases used in refrigeration and insulation.

The report suggests emissions trading would have too little an impact on wastewater management to bring about behavioural changes. In solid waste management, varying impacts on landfills with different standards could encourage diversion of waste towards landfills that control their gas emissions, and reinforce the current trend to close old, small landfills.

The report suggests that managing greenhouse gas emissions through introducing a price on emissions would be likely to have a significant impact on agricultural profitability. The report considers that the effect would be most pronounced for sheep and deer farming, but less pronounced for dairy and beef production where the cost would be smaller relative to product prices.

The forestry industry could benefit from the creation of credits for carbon dioxide sequestered by new plantings, but the report considers that, if obligations were placed on harvesting, those obligations would negate much of this benefit. The report predicts no new planting as a result of emissions trading. It also suggests that holders of forests planted before 1990 may be worse off if foresters are required to account for the carbon that, under the Protocol's rules, is assumed to be released when such forests are harvested without being re-planted. The report considers it likely that forest processing industries would also bear the impact of increased prices for energy and may lose competitiveness against processing in countries without emission obligations.

The report also considers how distributing emission units gratis, rather than selling them via auction, might alter the financial positions of businesses in different sectors. It finds that this would have varying effects, aiding the financial position of businesses in metal processing industries, but doing little to relieve the financial impact on deer farming.

Discussion

The results appear to show that an emissions price would result in large falls in output from some sectors. For example, if agricultural gases were subject to an emissions price, the model projects that dairy processing would show an output fall of between 16% and 25%. However, to get to that result, ABARE has assumed that there is an emissions price but no emissions-reducing research, no effects from the energy efficiency and conservation strategy, and no compensating economic policies put in place by the Government. It is highly unlikely that all of those negative assumptions would hold true, meaning that falls of 16–25% are unrealistic in practice.

Scenarios with an emissions price on agricultural methane and nitrous oxide consistently show worse overall macroeconomic effects in 2010 than scenarios where an emissions price is applied to carbon dioxide emissions only[9].

Sectoral output differences between scenarios are broadly proportional to the ratio of the international emissions prices between scenarios. For example, a halving of the emissions price would roughly halve a sectoral output reduction – provided the emissions price applied to the same range of emissions and industries in each scenario.

In scenarios where an emissions price applies to carbon dioxide only, ABARE assumes that there are no other policies at work to reduce emissions of methane and nitrous oxide. Because of this, the ABARE results show increasingly large falls in output from carbon dioxide emitting-industries as emissions prices are removed from methane and nitrous oxide. However, in reality, there would be non-price measures or other market instruments applying to the methane and nitrous oxide-emitting sectors that would reduce the burden on carbon dioxide emitting-industries.

[9] Before conclusions are drawn, however, it is important to bear in mind the caveats. First, this is a year 2010 "snapshot" only. It is possible that, under the model, there may be greater *long-term* economic impacts if such agricultural emissions are excluded from a price measure. Against that, the model's assumption is that no other measures would apply to such agricultural emissions, which is not realistic but is a limitation of the analysis technique.

It is important to note that these results are "snapshots" that represent the effects of an emissions price in the year 2010. They do not represent the longer-term (post-2013) effects of investment in lower-emitting capital as capital is replaced, adjustments to the global economy, further commitment periods, or the unavoidable fact that New Zealand will eventually run out of sink credits.

Comparison of findings

The different analytical techniques used in the ABARE and PA Reports, and the different purposes of the two analyses, limit the ability to directly compare the findings of the two reports. However, a brief comparison is made here as far as it is possible to do so.

Some points between the findings of the ABARE and the PA studies, such as the effects on coal, aluminium, and iron and steel production, are similar.

There are also some marked differences. Most noticeable are the potential impacts for dairy farming and processing, which ABARE identifies as one of the sectors bearing the deepest negative impact, but which the PA report suggests will be less affected than meat livestock production. Most scenarios examined by ABARE show positive effects for forestry, wood processing and pulp and paper, whereas the PA report is pessimistic on the prospects for new planting or processing arising out of a carbon-constrained economy. In this respect, the PA Report results are along the same lines as the findings of a qualitative report prepared by the New Zealand Institute of Economic Research for the Wood Processing Strategy. That report identified the "contingent liability" for emissions associated with the harvest (without re-planting) of pre-1990 forests as a significant concern for the forestry and related processing industries. A quantitative follow-up study is currently under way.

Some of these differences may be explained by the different approaches of the two studies. Since the ABARE modelling does not provide for forward-looking economic agents, it cannot explicitly account for any negative impact on forestry activity that might result from investors anticipating the future costs of obligations on deforestation. The more qualitative approach of the PA study could pick up such expectations, although the PA Study may not take into account the effect on the profitability of alternative land uses, especially dairying.

More generally, the results of the ABARE study show patterns of sectoral and aggregate macroeconomic results that are broadly consistent with those identified in earlier CGE modelling exercises, such as McKibbin and Pearce (2000) and Infometrics (2001).

Conclusion

The ABARE and PA Reports were commissioned to provide more up-to-date information than was available in early 2001 on possible effects for New Zealand of ratifying the Kyoto Protocol under different scenarios. In particular, the ABARE GTEM model was chosen because it had the advantages of:

- being internationally recognised and reviewed
- being a global computable general equilibrium model, able to take into account a broad range of socio-economic variables and account for global and domestic market adjustments
- covering methane and nitrous oxide, as well as carbon dioxide
- including detailed coverage of primary industry sectors and
- providing a basic treatment of forest sinks.

The GTEM was used for exploratory analysis to gain an understanding of the possible range of effects on New Zealand of different domestic and overseas arrangements for implementing the Kyoto Protocol. The findings are in "raw form"; that is, they do not include any policies that could mitigate sectoral effects of an emissions price, and they do not make judgements as to whether effects are acceptable or not. GTEM shares the limitations that are common to all CGE models, such as not being able to account for technological advances or non-market measures, and assuming zero transactions and adjustment costs.

The PA Report examined the effects of an emissions trading scheme on selected sectors of the New Zealand economy using a structure-conduct-performance approach rather than finding market equilibria based on an input-output table as GTEM does. The pattern of effects was similar in each study, although the whole-economy focus of GTEM, along with its capacity to account for economic adjustments beyond the direct effect of an emissions price, suggests that its findings should generally be accorded the greater weight. The exception may be for those sectors where it can be demonstrated that the GTEM representation is clearly at odds with the real-world situation.

It is extremely important to be aware that, while GTEM is considered the best model available to assess broad-level aggregate and sectoral effects of emissions prices on the New Zealand economy, the model is an abstraction from reality. No scenario modelled can fully reflect the complex policy response that is likely in practice. The results should therefore be considered as only broadly indicative of the possible adjustments in some sectors, in the absence of mitigation policies, non-price and alternative market instruments. As such, it is an information-gathering tool only, to provide a basis on which informed future decisions may be made.

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Annex 1: Interpreting the results of the ABARE model

The ABARE report is based on a mathematical model of the New Zealand and world economies. The model is used to predict how the New Zealand economy would adjust if new policies were introduced to manage greenhouse gas emissions. The model generates new values for national economic measures, such as gross domestic product, and exports and imports, and for industry sector economic measures, such as industry production and employment levels.

The results of two of the scenarios modelled by ABARE are presented below, along with the contextual information that needs to be considered when interpreting the ABARE modelling results. This is to make clear how and why the scenario results provide indicative information only, and do not necessarily present the likely outcome of final decision making.

These two scenarios assume that the US does not ratify the Protocol, but all other developed countries do. In one of the scenarios, New Zealand alone among developed nations puts an emissions price on agricultural methane and nitrous oxide emissions. The second scenario assumes that no developed countries (including New Zealand) apply such a price. In both scenarios, an emission price is applied to carbon dioxide emissions.

Example 1: Emissions price on all gases
(Scenario 2 in the ABARE report)

These tables help illustrate how the advantages and disadvantages of computable general equilibrium (CGE) modelling show up in the results, along with technical points regarding some of the measures reported. While these tables are copied from the ABARE report, they are given here purely as an example. For a full **presentation** and **discussion** of the modelling results, readers are referred to the ABARE Report.

Table 5: The carbon market and economic impacts in New Zealand under scenario 2 at 2010

The carbon market		
Carbon charge	US$ per tonne of carbon	108.4
Net quota income	US$ million	560.2
Net quota sales	Mt of CO_2 equivalent	19.0
Domestic abatement	Mt of CO_2 equivalent	14.9
Economic impact relative to the reference case		
GDP	%	-0.26
GNP	%	0.05
Exchange rate	%	-1.22
Exports	%	-2.60
Imports	%	-1.72
Savings	%	-1.15
Investment	%	-0.22
Export price index	%	-0.22
Import price index	%	-0.03
Terms of trade	%	-0.19
Rate of return on capital	%	-2.78
Real wage	%	-2.36

NZ$72 per tonne CO_2 - At the high end of the range from international modelling

GNP (or GNI, for Income) is a more complete measure of national income than GDP.

National income (GNP) increases, even though GDP falls

CGE modelling accounts for flow-on changes all through the economy, not just the direct emissions price.

These results:

- assume that an emissions price will apply to all emissions of carbon dioxide, methane and nitrous oxide – which may not be the policy decision made in New Zealand
- come from exploration of possible scenarios. They do not make judgements about which possible policies might "better" or "worse". Importantly, they provide information to help make decisions (as opposed to working on the assumption that decisions have already been made).

Table 6: Change in sectoral outputs in New Zealand under scenario 2 at 2010, relative to the reference case

	%
Coal	–14.7
Gas	–6.1
Petroleum and coal products	–2.1
Electricity	–5.6
Iron and steel	–17.6
Nonferrous metals	–6.9
Meat products	–4.7
Dairy products	–25.2
Food products	2.2
Light manufacturing	3.2
Trade and transport	1.0
Private services	0.8
Crops	12.3
Forestry	2.7
Livestock for meat	–6.8
Other animal products	6.2
Dairy cattle	–20.5
Wool	–28.8

Emissions intensive industry output falls, but the model assumes no offsetting policies such as revenue recycling or allocation, does not allow for technology improvements or energy efficiency, and does not allow for non-price measures that could be put in place instead of an emissions price.

Dairying (and wool below) show the biggest output falls – but this assumes that NZ, and NZ alone, would put a price on every unit of agricultural emissions, and that it would provide no offsetting policies or emissions reducing research.

These large low-emitting sectors show increases in output as resources move from emissions intensive sectors.

The model does not link sink credit income into the forestry sector – all new post-1990 forests will attract sink credits…

…but some qualitative analyses do not agree with these CGE results

Example 2: Emissions price on all gases except agricultural methane and nitrous oxide

(Scenario 3 in the ABARE report)

Table 7: The carbon market and economic impacts in New Zealand under scenario 3 at 2010

The carbon market		
Carbon charge	US$ per tonne of carbon	109.7
Net quota income	US$ million	258.2
Net quota sales	Mt of CO_2 equivalent	8.6
Domestic abatement	Mt of CO_2 equivalent	4.6
Economic impact relative to the reference case		
GDP	%	-0.10
GNP	%	0.43
Exchange rate	%	0.03
Exports	%	-0.04
Imports	%	0.16
Savings		0.46
Investment		-0.05
Export price index		0.08
Import price index		-0.03
Terms of trade		0.12
Rate of return on capital	%	-1.85
Real wage	%	-1.36

Again, high end price (NZ$73 per tonne CO_2)

GNP is a measure of welfare - but the model cannot account for any related benefits of climate change policies, like lowered healthcare costs, and so these are not counted in GNP.

The gain in national income (GNP) is much bigger this time, and the GDP loss is smaller.

Again, the advantage of CGE over other types of study is that it allows all of these important, related economic variables to adjust.

Table 8: Change in sectoral outputs in New Zealand under scenario 3 at 2010, relative to the reference case

	%
Coal	–16.4
Gas	–6.9
Petroleum and coal products	–2.5
Electricity	–6.2
Iron and steel	–22
Nonferrous metals	–12
Meat products	–1
Dairy products	–0.4
Food products	0.4
Light manufacturing	–0.9
Trade and transport	0
Private services	0.4
Crops	0.6
Forestry	0.8
Livestock for meat	–0.1
Other animal products	0.3
Dairy cattle	–0.3
Wool	0

When a price is on CO_2 only, steel shows the biggest output fall. The model assumes that, without a price, nothing happens in agriculture, including projects, research or other sector measures. This means the model forces all the adjustment on to CO_2 intensive industries. This is highly unlikely to occur in practice.

Again, the model does not allow for offsets to taxes, or gratis emission unit allocation to assist competitiveness, or for the possibility of non-price measures in competitiveness-at-risk sectors.

Dairy production is barely affected under this scenario – the small decline is because of the price on CO_2. Even this does not allow for the policies described above, or for benefits that might flow from energy efficiency measures or research.

Again, all CGE modelling shows gains to forestry, even without the effect of sink credits being included.

New technologies and business opportunities will come out of the Protocol – but the model cannot account for these so they are not shown.

Summary

The results shown in Example 1 and Example 2 indicate the possible effects of direct emissions prices under strict assumptions. Technical points that come out of these results are that they are "worst case" – they do not allow for all the possible mitigating options, like effects of research, energy efficiency or benefits through business opportunities. Policy questions that could come out of these scenarios are:

- Should we use an emissions price instrument?
- If so, should it apply to all gases?
- To all sectors?
- Should there be special measures for emissions-intensive industries that face import or export competition?
- If there is revenue from a price instrument, how could it be used?