THE EARLY ABARE REPORT

IMPORTANT NOTE FOR READERS

The attached report, *The Economic Impacts of Selected Climate Change Policy Options for New Zealand*, was prepared in draft form between April and July 2001. It was based on US participation in the Kyoto Protocol.

In light of the US decision not to participate in the Protocol and of the outcome of the resumed COP 6 meeting in Bonn in July 2001, finalisation of the attached report was put on hold. A second ABARE report - *Economic outcomes of the Kyoto Protocol for New Zealand* - was commissioned in September 2001.

Consultation on ratification of the Kyoto Protocol and on policy options for New Zealand to meet its obligations was informed by the second ABARE report. That report was more relevant to ratification than the attached report because it assumed the US did not take part in the Protocol.

The early ABARE report, *The Economic Impacts of Selected Climate Change Policy Options for New Zealand,* was subsequently completed but has largely been overtaken by events.

The report's findings must be treated with caution in relation to their magnitudes because of the non-participation of the United States and because of changes to the rules regarding the commitment period reserve and Article 3.4 sinks at COP-6 and COP-7.

The findings are limited in terms of assessing the possible effects of ratifying the Protocol for New Zealand.

The scenarios modelled do not indicate any policy preferences on the part of the Government.

Economic impacts of selected climate change policy options for New Zealand

ABARE
Innovation in Economic Research

Economic impacts of selected climate change policy options for New Zealand

ABARE report
to New Zealand Ministry of Agriculture and Forestry

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ABARE
Innovation in Economic Research

CLIMATE CHANGE NEW ZEALAND

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ABARE project 2619

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Introduction

The world community adopted the Kyoto Protocol in December 1997 at the third Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3). The main achievement was agreement by developed (Annex B) countries to reduce or limit their combined greenhouse gas emissions to 5.2 per cent below 1990 levels for the commitment period, 2008–12. As part of this agreement, New Zealand committed to restrict its greenhouse gas emissions to 1990 levels from 2008–12.

Since the adoption of the Kyoto Protocol the international climate change policy debate has focused on establishing rules that will enable the protocol to be implemented. Rules governing the economic instruments, particularly emissions trading and the clean development mechanism, and the use of sinks in the protocol have been central to this debate. During 2001 this debate has narrowed in focus after the United States' withdrawal from the protocol in March and the agreements made at the resumption of COP6n in Bonn and at COP7 at Marrakech in July and November respectively. At Bonn the Annex B countries remaining in the protocol developed important detail on issues such as emissions trading, sinks, finance to developing countries and compliance. This detail was further clarified in Marrakech.

The implementation rules governing the Kyoto Protocol are of particular importance to New Zealand, where substantial sink credits are potentially available through forestry activities. Also of importance to New Zealand are issues associated with the domestic implementation of the protocol and, in particular, its treatment of the agriculture sector, which is responsible for over half of New Zealand's greenhouse gas emissions.

Prior to the resumption of the sixth Conference of the Parties in Bonn, the New Zealand Ministry of Agriculture and Forestry commissioned ABARE to analyse a set of scenarios developed by the New Zealand Ministry of Agriculture and Forestry for its pre-ratification assessment of the Kyoto Protocol. These scenarios cover a broad range of domestic and international climate change response policies but, given the timing of their design, do not reflect the implications of recent developments, such as the outcomes negotiated in Bonn and Marrakech and the decision of the US government not to ratify the protocol. Subsequent to this analysis, ABARE has released two reports that incorporate

these more recent developments. ABARE 2001 'Economic outcomes of the Kyoto Protocol for New Zealand' analyses the implications of the Kyoto Protocol for New Zealand incorporating the decision of the US government not to ratify the protocol.

Results of ABARE's most recent analysis, including the Bonn outcome and the US decision, are contained in ABARE conference paper 2001.28, 'The Kyoto Protocol: economic impacts under the terms of the Bonn agreement' (Jakeman et al. 2001), which is available on the ABARE website (www.abareconomics.com).

1 *Description of scenarios modeled in this study*

Scenario	Description
1	Base modeling scenario: implementation of the Kyoto Protocol with full emission quota trading, Article 3.3 sinks and all Annex B countries participating but without the clean development mechanism
2	Same as (1) but with clean development mechanism included
3	Same as (1) but with estimated sink credits under Article 3.4 included
4	Same as (1) but with all countries maintaining a 90 per cent commitment period reserve
5	Same as (1) but with the carbon charge applying only to carbon dioxide emissions
6	Same as (1) but with zero abatement possibilities in New Zealand agriculture
7	Same as (1) but with high level of abatement possibilities in New Zealand agriculture
8	Same as (5) but with New Zealand agriculture having incentives to abate emissions via a domestic project based emissions trading system
9	Same as (1) but with New Zealand sink credits limited to 75 per cent of available total
10	Same as (1) but with the New Zealand government using carbon charge revenue to fund a reduction in company taxes
11	Same as (1) but with the carbon charge applying only to carbon dioxide emissions and no sinks — this scenario is run to 2020
11a	Same as (11) but with New Zealand introducing a carbon tax between 2003 and 2007
12	Same as (1) but with eastern Europe and the Russian Federation and the Ukraine not participating in emission quota trading

A full list of the scenarios modeled in this analysis is provided in table 1. Four broad categories of scenarios are considered in the study:

- The first category is a base scenario and assumes the implementation of the Kyoto protocol with participation by all Annex B countries (scenario 1). Although results in this analysis are reported relative to a reference case in which the Kyoto Protocol is not implemented, this scenario forms a useful basis from which to compare the other scenarios undertaken.
- The second category includes a set of scenarios that explore issues relating to the design of the Kyoto Protocol (scenarios 2–4). These scenarios analyse issues that are being considered in the context of the international climate change negotiations, including the clean development mechanism and sink activities. It should be noted that these scenarios were designed prior to the negotiations in Bonn and do not reflect the outcomes of those negotiations.
- The third category includes a set of scenarios that consider important implementation issues such as the coverage of greenhouse gases and sources, providing subsidies for abatement activities and the use of revenue obtained from a carbon charge (scenarios 5–11a).
- The fourth category includes a scenario that considers the participation of the Russian Federation, the Ukraine and eastern Europe in the protocol (scenario 12).

Analytical framework

The analysis of climate change policies in this study is based on scenario results from ABARE's general equilibrium model of the world economy, GTEM. GTEM is a dynamic model developed at ABARE to address policy issues with long term, global dimensions, such as climate change. It is derived from the Megabare model (ABARE 1996) and the GTAP model (Hertel 1997). A detailed description of GTEM features can be found in Brown et al. (1999) and a full specification of the model can be viewed on ABARE's web page (www.abareconomics.com).

The GTEM database (based on the GTAP 4.0e database) contains 55 sectors and 45 regions. For this study, the database is aggregated to the 23 regions and 33 commodities that allow a detailed representation of Annex B countries and emission intensive industries, particularly in agriculture.

GTEM models emissions of three greenhouse gases — carbon dioxide, methane and nitrous oxide. In Annex B regions, carbon dioxide, methane and nitrous oxide account for around 99 per cent of anthropogenic greenhouse gas emis-

sions on a carbon dioxide equivalent basis, excluding land clearing (United Nations 1999).

The emissions coverage in GTEM accounts for almost 96 per cent of greenhouse gas emissions in New Zealand. GTEM does not include emissions from waste, emissions from agricultural residues or methane and most nitrous oxide emissions from combustion and some industrial processes. However, nitrous oxide emissions from combustion in the transport sector are included in GTEM.

Reference case

The GTEM reference case provides a representation of the world economy over the period 1996–2020 in the absence of policies designed to reduce greenhouse gas emissions. The projections from a policy scenario are compared with results from the reference case to estimate the effects of implementing a policy change under the Kyoto Protocol to be isolated.

New Zealand macroeconomic projections

The GTEM reference case results are driven by projections of real gross domestic product (GDP) for each country. These projections are based on ABARE (2000) and IMF (2000) forecasts and on convergence theory, under which it is assumed that per worker real GDP converges toward that of the United States after 2005. In this report, the real GDP data for New Zealand were supplied by the New Zealand Ministry of Agriculture and Forestry.

It should be noted that GTEM is a long run sectoral model of the world economy. It is not designed to capture the detailed interaction of macroeconomic variables over the business cycle. However, the GTEM reference case used in this analysis does display the following characteristics of New Zealand's recent macroeconomic history:

- growth in the quantity of domestic investment exceeds growth in the quantity of domestic savings, leading to an accumulation of foreign debt;
- the value of exports in New Zealand grows with the value of imports;
- the current account continues to deteriorate owing to the large interest payments New Zealand must make on its foreign debt;
- these interest payments cause real GDP to grow more rapidly than real gross national product (GNP) in New Zealand.

The reference case projections for key macroeconomic variables in New Zealand are shown in table 2. These variables include real GDP, real GNP, the

real exchange rate, the quantity of exports, imports, savings and investment and the terms of trade. It should be noted that in this report, contrary to regular GTEM protocol, an appreciation of the real exchange rate is denoted by a positive change in the real exchange rate as reported in the results tables.

2 *Projected average annual change in New Zealand macroeconomic indicators, 1995–2010 – reference case*

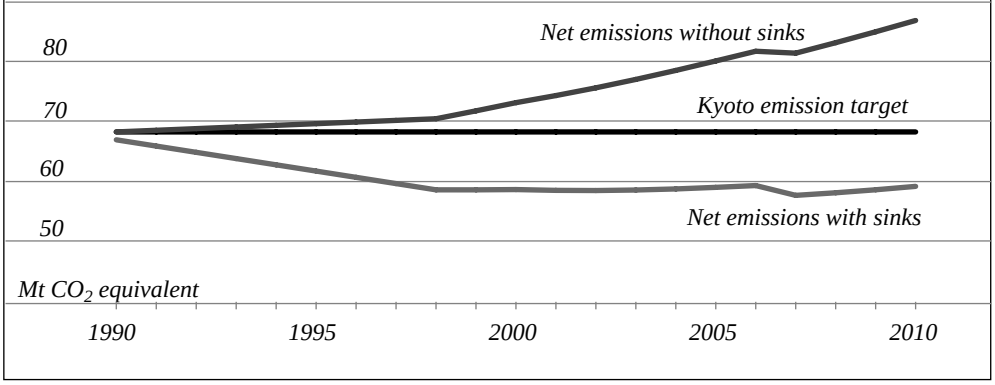
	%
GDP	2.6
GNP	1.7
Exchange rate	–0.1
Exports	2.5
Imports	2.8
Terms of trade	0.3
Savings	1.7
Investment	5.8

New Zealand emission projections

Under the Kyoto Protocol, New Zealand is required to maintain its net greenhouse gas emissions at 1990 levels over the first commitment period, 2008–12. Over the reference case New Zealand's net greenhouse gas emissions, excluding carbon sequestered by forestry activities, are projected to grow from 68.3 million tonnes of carbon dioxide equivalent in 1990 to 86.8 million tonnes at 2010 (figure 1). However, carbon sequestration by forest sinks under Article 3.3 is projected to generate 138 million tonnes of carbon dioxide equivalent sinks over the first commitment period, or an average of 27.6 million tonnes a year (New Zealand Ministry for the Environment 2000b). These carbon sinks are projected to reduce New Zealand's net greenhouse gas emission to 59.2 million tonnes of carbon dioxide equivalent at 2010.

On a sectoral level, the major changes in New Zealand's emissions profile over the reference case are projected to originate in the livestock and electricity generation industries. Emissions from dairy cattle are projected to grow rapidly

1 *New Zealand reference case emissions*



while emissions from livestock for meat production are projected to increase slightly and emissions from wool production are projected to fall marginally. These disparate emission growth rates reflect the current movement of livestock producers toward dairy production, which is assumed to continue over the period to 2010. Emissions from electricity generation are projected to grow more rapidly than in any other sector as limited expansion possibilities in hydro-electricity generation are projected to lead to greater use of relatively emission intensive coal and gas fired electricity plants.

Economic impacts of emission abatement policies

For the scenarios reported in this study, the economic impacts of emission abatement policies are measured as the percentage changes in both real gross national product (GNP) and real gross domestic product (GDP) relative to the reference case levels. Real GNP is equal to real gross domestic product (GDP) plus net foreign income transfers, and therefore provides a complete measure of the flow of income available to an economy for consumption, savings and depreciation. In the New Zealand context, changes in real GNP can be attributed to three main areas;

GNP effect = output effect (GDP) + terms of trade effect
+ net income transfer

A major source of the economic costs of implementing the Kyoto Protocol are the output effects associated with imposing a carbon charge on greenhouse gas emitters. These include increased costs of producing emission intensive products and increased consumer prices. In addition, as the costs of producing emission intensive commodities increase, the incentive to relocate these industries to non-Annex B regions is increased.

Terms of trade effects will arise because actions to limit emissions in Annex B countries affect the relative prices of products traded on world markets. For example, the imposition of a carbon charge (on a comprehensive basis) will lead to higher costs of production in the livestock industries and in energy intensive products, such as iron and steel production.

Income transfers under international emissions trading arise from the purchase and sale of emission quota and sink credits. The extent to which Annex B countries can use quota purchases (sales) to meet their targets also affects the economic cost of emission abatement under the protocol.

Scenario results

The results for major New Zealand macroeconomic aggregates under each scenario are presented in table 3.

Base scenario

Implementing the Kyoto Protocol under the base scenario is projected to result in a carbon charge of almost US$145 a tonne of carbon across Annex B countries (in this report all values are reported in 2001 dollars). At this carbon charge, Annex B countries trade 2.44 billion tonnes of carbon dioxide equivalent. Most of this quota trade occurs between the United States, which purchases 1.69 billion tonnes and the Russian Federation and the Ukraine, which are projected to sell 2 billion tonnes. Among other Annex B countries, eastern European countries are projected to sell 416 million tonnes of carbon dioxide equivalent of emission quota and the European Union is projected to buy 274 million tonnes of emission quota.

The base scenario results in a reduction in economic activity but an increase in national income in New Zealand compared with the reference case (table 3). At 2010, New Zealand's real GDP is projected to be 0.20 per cent lower

3 ***Key results for New Zealand under each scenario at 2010***

Scenario	Carbon charge	Carbon charge	Net quota income	Quota sales	Domestic abatement [a]	GDP	GNP
	US$/t C	US$/t CO_2	US$m	Mt CO_2 equiv.	Mt CO_2 equiv.	% diff. from ref. case	% diff. from ref. case
1	144.7	39.5	982.8	24.9	43.2	–0.20	2.08
2	138.7	37.8	926.3	24.5	42.6	–0.18	1.98
3	121.8	33.2	742.1	22.3	40.7	–0.15	1.66
4	245.3	66.9	490.1	7.3	–1.9	0.25	3.37
5	177.7	48.5	739.9	15.3	33.5	–0.06	2.08
6	144.7	39.5	951.6	24.1	42.4	–0.22	1.96
7	144.6	39.4	1015.6	25.8	44.0	–0.18	2.20
8	177.6	48.4	797.1	16.5	34.7	–0.05	2.19
9	145.2	39.6	709.6	17.9	36.2	–0.23	1.53
10	144.7	39.5	955.2	24.2	42.4	–0.16	2.07
11	170.5	46.5	–625.8	–13.5	4.9	–0.24	–0.71
11a	170.8	46.6	–601.8	–12.9	5.6	–0.24	–0.66
12	576.9	157.3	7678.3	48.8	67.1	–1.20	13.23

a Includes reduction in net emissions from sequestration activities.

than reference case levels as a result of the negative output effects of the carbon charge. These economic costs are more than offset by the foreign income of US$983 million generated by New Zealand's sales of emission quota on the international emission quota market. At 2010 New Zealand's real GNP is projected to be 2.08 per cent above its reference case level.

At the sectoral level, imposing the carbon charge under base scenario assumptions is projected to shift production in New Zealand from emission intensive sectors such as agriculture, metals and electricity production into less emission intensive industries, such as services, light manufacturing, cropping and forestry. In New Zealand's agriculture sector, wool and dairy production is being substituted, to some extent, for beef production, which is less emission intensive than wool and dairy production. The projected reduction in wool and dairy activity also leads to a reallocation of agricultural land to crops.

Protocol design scenarios

The protocol design scenarios assess the effects of three major issues in the international climate change negotiations: the clean development mechanism; the commitment period reserve; and the inclusion of sinks under Article 3.4 of the protocol. Again, while these scenarios were designed prior to the negotiations in Bonn they do provide valuable insights for evaluating the outcomes from the resumption of COP6 in Bonn and from COP7.

Clean development mechanism

For this scenario the assumptions of the base scenario still hold. In addition, for each year of the commitment period, just over 90 million tonnes of carbon dioxide equivalent are made available to Annex B regions under the clean development mechanism. This additional abatement, sourced from technology transfer and forestry projects, is projected to reduce the carbon charge from US$145 a tonne of carbon equivalent under the base scenario to US$139 a tonne of carbon equivalent.

Introduction of the clean development mechanism is projected to reduce sales of emission quota from New Zealand relative to the base scenario, as low cost emission quota is supplied by non-Annex B countries. Under the clean development mechanism, real GNP in New Zealand is projected to rise by 1.98 per cent relative to the reference case at 2010 (as opposed to a 2.08 per cent rise under the base scenario).

Article 3.4 sinks

In modeling the impact of including Article 3.4 sinks under the Kyoto Protocol (scenario 3) the assumptions underpinning the base scenario hold. It is also

assumed that, over the commitment period, all Annex B regions except New Zealand can access emission reductions equal to 3 per cent of their assigned amount under Article 3.4. Implementing the Kyoto Protocol with Article 3.4 sinks is projected to result in a carbon charge of just under US$122 a tonne of carbon equivalent, which is lower than the carbon charge established under the base scenario because of the reduced demand from Annex B regions.

For this scenario, New Zealand is projected to sell 22.3 million tonnes of carbon dioxide equivalent worth US$742 million, leading to a rise in real GNP of 1.66 per cent relative to the reference case at 2010. These values are below the level for the base scenario because, unlike the other Annex B countries, New Zealand is assumed not to earn any emission reductions from activities under Article 3.4 (figures for Article 3.4 for New Zealand were supplied by the New Zealand Ministry of Agriculture and Forestry). For other Annex B countries, emission credits under Article 3.4 reduce demand for emission quota from New Zealand relative to the base scenario. Economic activity in New Zealand does not fall by as much as under the base scenario because of a lower carbon charge.

Commitment period reserve

Introduction of the Kyoto Protocol with a 90 per cent commitment period reserve (scenario 4) restricts the amount of emission quota a country can sell by requiring it to hold 90 per cent of its emissions in its national inventory. In other respects this scenario is identical to the base scenario. Implementing the Kyoto Protocol with a 90 per cent commitment period reserve is projected to result in a carbon charge of US$245 a tonne of carbon equivalent, which is significantly higher than under the base scenario.

Under this scenario New Zealand is restricted to selling 7.3 million tonnes of carbon dioxide equivalent emission quota worth US$490 million (compared with selling 24.9 million tonnes of emission quota under the base scenario). At this level of sales, New Zealand has significant volumes of low cost emission abatement that it cannot sell on the emission quota market. This results in the marginal cost of abatement in New Zealand remaining below the global charge. The low marginal cost of abatement reduces the costs of producing emission intensive goods in New Zealand below those in Annex B countries with higher marginal costs of abatement. As a result, New Zealand expands production of wool and meat products, iron and steel and electricity while still meeting its Kyoto emissions target. Overall, economic activity in New Zealand is projected to increase by 0.25 per cent relative to the reference case at 2010, while New Zealand's real GNP is projected to increase by 3.37 per cent relative to the reference case at 2010.

Issues of implementation

This category of scenarios addresses a range of issues relating to how New Zealand could implement the Kyoto Protocol. The issues include options for the coverage of greenhouse gases and sources that can be taxed under a climate change policy, the roles of agriculture and forest sinks, recycling of revenue from a carbon charge and early abatement action.

Restricted coverage of gases

Under this scenario (scenario 5), Annex B countries only apply a carbon charge to carbon dioxide emissions, although methane and nitrous oxide emissions are still included in each country's emission target. With methane and nitrous oxide emissions not exposed to the carbon charge under this scenario, many countries lose access to low cost abatement options, resulting in an increase in the carbon charge from US$145 a tonne of carbon equivalent under the base scenario to US$178 a tonne.

The smaller carbon charge under this scenario results in a smaller fall in economic activity in New Zealand than under the base scenario. Emissions of methane from livestock industries, which constitute a significant share of New Zealand greenhouse gas emissions, do not face the carbon charge. As such, New Zealand's exports of agricultural products do not fall as far under this scenario as they do under the base scenario. As a seller of emission quota New Zealand also benefits from emission quota trading, earning almost US$740 million from the sales of emission quota. This leads to real GNP in New Zealand rising 2.08 per cent above the reference case at 2010, equalling the change in GNP for the base scenario.

Alternative abatement options in the New Zealand livestock sector

Two scenarios were run to test the impact of alternative abatement possibilities in the New Zealand livestock sector on the costs of implementing the protocol in New Zealand (scenarios 6 and 7). Under the 'low abatement' scenario (scenario 6) it is assumed that the New Zealand livestock sector cannot abate any methane without reducing output — that is, its access to emissions saving technologies is zero. Under the 'high abatement' scenario (scenario 7) it is assumed that the New Zealand livestock sector is able to abate twice as much methane without reducing output than was possible for the base modeling scenario at each carbon charge.

As New Zealand is a small country, these changes to New Zealand's abatement possibilities have only minimal impact on the carbon charge and emission quota market. However, within New Zealand these changes are significant. A higher level of abatement possibilities in agriculture reduces the marginal

cost of abatement in New Zealand, enabling New Zealand to undertake more domestic abatement and sell more emission quota on the international market while still meeting its emissions target. Both real GNP and real GDP in New Zealand are slightly higher when there are greater opportunities for abatement in agriculture, relative to the base scenario. The reverse is true under the low abatement scenario.

Subsidising New Zealand livestock producers for methane abatement
This scenario examines, under the assumptions of restricted coverage, a scheme by which New Zealand farmers are subsidised to reduce agricultural emissions to base scenario levels (scenario 8). As New Zealand is a small country, the introduction of this subsidy does not significantly alter the carbon charge established under restricted coverage (scenario 5), which remains at around US$178 a tonne of carbon equivalent.

The main effect of this scheme is to increase the amount of emission quota that New Zealand is able to sell to other Annex B countries while still meeting its Kyoto requirements. Compared with the restricted coverage scenario, subsidising emission reductions in agriculture is projected to lead to an increase in domestic abatement in New Zealand, which in turn increases the amount of income that New Zealand receives from sales of emission quota. This leads to a rise in real GNP relative to both the base scenario and the restricted coverage scenario.

Restricted sales of sinks
Under this scenario (scenario 9), the availability of sink credits under Article 3.3 in New Zealand is reduced to 20.7 million tonnes of carbon dioxide equivalent (75 per cent of the base scenario level). The reduction of 7 million tonnes of carbon dioxide equivalent in sink credits has a small impact on the emission quota market, causing the global carbon charge to rise from US$144.70 a tonne of carbon under the base scenario to US$145.20 a tonne of carbon.

The decline in income from the sale of sink credits, relative to the base scenario, reduces real GNP growth in New Zealand to 1.53 per cent above the reference case at 2010 (compared with real GNP growth of 2.08 per cent under the base scenario). Despite New Zealand undertaking less domestic abatement in this scenario than in the base scenario, economic activity in New Zealand, measured in terms of GDP, falls further as consumers have less income to spend on goods and services.

Recycling of revenue from a carbon charge
This scenario (scenario 10) assumes that the New Zealand government uses the revenue it receives from the carbon charge to fund a reduction in New Zealand company tax rates. In the base scenario, revenue from the carbon

charge was returned in a lump sum fashion to households in New Zealand. This policy does not alter the carbon charge from its base scenario level.

This policy reduces the cost to companies of implementing the Kyoto Protocol, which leads to a smaller fall in economic activity than that which occurred in the base scenario. However, the relative increase in economic activity reduces domestic abatement in New Zealand to 42.4 million tonnes of carbon dioxide equivalent (as opposed to 43.2 million tonnes under the base scenario). Accordingly, New Zealand sells less emission quota under this scenario than under the base scenario. The real GNP in New Zealand rises by 2.07 per cent relative to the reference case at 2010, which is slightly below the level for the base scenario.

Restricted gas coverage (with the exclusion of sinks) – short and long term impacts

This scenario assumes the Kyoto Protocol is implemented with restricted coverage on greenhouse gases and without access to Article 3.3 sinks (scenario 11). Under this scenario the carbon charge is reduced from around US$178 a tonne of carbon under restricted coverage (scenario 5) to US$170 a tonne of carbon. This reduction occurs because activities under Article 3.3, as reported in Annex B countries' 1 August 2000 submissions to the UNFCCC (www.unfccc.int/resource/docs/2000/sbsta/09a1.pdf), are projected to result in a net greenhouse gas emission over the first commitment period, 2008–12.

Despite the lower carbon charge globally, New Zealand is considerably worse off in this scenario than in previous scenarios because it is not allowed to count its 27.6 million tonnes of carbon dioxide equivalent of sinks under Article 3.3 toward meeting its Kyoto emissions target. Without these sinks New Zealand is projected to become a net buyer on the emission quota market, paying almost US$626 million to buy 13.5 million tonnes of carbon dioxide equivalent of emission quota. This significant income loss is projected to reduce real GNP in New Zealand relative to the reference case, which in turn is projected to reduce economic activity relative to the reference case through reduced demand for goods and services.

The carbon charge is projected to roughly double to $US367 a tonne of carbon by 2020 (table 31). This is because, despite holding the emission level fixed to 2020 across Annex B regions, the actual emission abatement task (the difference between reference case emission and target emissions) increases. As the emission abatement task is increased, low cost options to reduce emissions become more scarce. This results in the carbon charge rising further, shifting the behavior of firms and consumers to adopt alternatives to emission intensive practices and commodities.

Early abatement action

In this scenario New Zealand is assumed to unilaterally introduce a carbon charge of US$25 a tonne of carbon equivalent in 2003 (scenario 11a). It is also assumed that the Kyoto Protocol is implemented with restricted coverage and without Article 3.3 sinks in 2008. This policy results in much the same carbon charge as scenario 11.

Under a policy of early abatement action, the carbon charge levied from 2003 to 2007 encourages early emission abatement in New Zealand over this period. When a full Annex B trading scheme is established, New Zealand has already undertaken unilateral domestic action that, at 2010, leads to a greater level of domestic abatement than when early abatement action is not undertaken. This leads to a lower reliance on the purchase of domestic quota by 2010 and a small reduction in adverse real GNP effects compared with scenario 11.

By undertaking early abatement action New Zealand is subject to abatement costs earlier than in the other scenarios. In 2003, when the early action policy is implemented, the net present value (using a 7 per cent discount rate) of the economic costs over the period 2003 to 2010 is US$139 million higher than when no early abatement action is taken. However, discounting these costs over the period to 2020 results in the costs of implementing the Kyoto Protocol under an early action policy being US$412 million lower than if no early abatement action is taken.

Country participation

The Russian Federation, the Ukraine and eastern Europe do not ratify the Kyoto Protocol

Implementing the Kyoto Protocol under base scenario assumptions but without the participation of the Russian Federation, the Ukraine and eastern Europe (scenario 12) will significantly reduce access to low cost emission quota for Annex B countries. This will lead to a significant rise in the carbon charge when compared with the base scenario. As a net seller of emission quota, New Zealand will undertake additional domestic abatement to increase its sales of emission quota relative to the base scenario. This foreign income is projected to more than offset the decline in economic activity resulting from the higher carbon charge and the higher level of domestic abatement.

1. Introduction

The world community adopted the Kyoto Protocol in December 1997 at the third Conference of the Parties to the United Nations Framework Convention on Climate Change (COP3). The main achievement of the protocol was an agreement by developed (Annex B) countries to reduce or limit their combined greenhouse gas emissions to 5.2 per cent below 1990 levels for the commitment period, 2008–12 (a summary of the Kyoto Protocol is presented in box 1).

Since the adoption of the Kyoto Protocol the international climate change policy debate has focused on establishing rules that will enable the protocol to be implemented. Rules governing the economic instruments and the use of sinks in the protocol have been central to this debate. The issue of further commitments for developing countries in assisting to mitigate the adverse effects of climate change has also been important.

Member countries of the UNFCCC met in the Hague in November 2000 at the sixth Conference of the Parties (COP6) with the aim of resolving some of the major outstanding issues in the Kyoto Protocol (a summary of the outcomes of COP6 can be found in Polidano et al. 2001). Parties were unable to reach agreement on several issues and COP6 was suspended. One of the key issues discussed at COP6 was the use of mechanisms such as emissions trading. The European Union proposed to limit the amount of emission quota that can be traded internationally, claiming that, in large measure, Kyoto targets should be met through real and measurable efforts at home, rather than through the purchase of credits abroad. The Umbrella Group (Australia, the United States, Canada, Japan, New Zealand, the Russian Federation, the Ukraine, Iceland and Norway) opposed this view, maintaining that restrictions on trade would unnecessarily increase the cost of complying with the Kyoto Protocol.

Following the suspension of COP6 and prior to its resumption in July 2001, President Bush announced that the United States would not ratify the protocol.

COP6 was resumed in July 2001 at Bonn and agreement was reached on the implementation of the Kyoto Protocol (without US participation). Detail on issues such as mechanisms, sinks, finance to developing countries and compliance were developed. However, with the exception of finance to developing countries the Bonn agreement still required further negotiations before becoming operational. In November 2001, at COP7 in Marrakech, consider-

Box 1: ***The Kyoto Protocol***

Background
Under the Kyoto Protocol, adopted at the third Conference of the Parties (COP3) in December 1997, developed (Annex B) countries must aim to reduce their aggregate emissions of greenhouse gases to 5 per cent below 1990 levels over the first commitment period, 2008–12. The six greenhouse gases covered by the protocol are carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride.

Whether a party meets its commitments will be assessed by comparing its adjusted assigned amount with its emission inventory averaged over the period 2008–12. An average is used to reduce the influence of annual fluctuations in emission levels that could be caused by factors such as unusual weather conditions or cyclical changes in economic activity.

A party's assigned amount is the amount of greenhouse gases it can emit over the first commitment period. It is calculated by multiplying its base year emissions (generally 1990 emissions) by its emission limitation or reduction commitment (listed as a percentage of its base year emissions under Annex B of the protocol), and multiplying this by five. For most countries, calculation of the base year emissions does not include land use change and forestry (see the section on Article 3.7 for exceptions.)

A party's assigned amount can be adjusted through buying or selling emission credits under the mechanisms.

Mechanisms
To achieve their emission abatement commitments, Annex B parties are permitted to use the Kyoto mechanisms — provisions in the protocol that convey flexibility in the location of emission abatement actions. The Kyoto mechanisms are international emissions trading, joint implementation, the clean development mechanism and the EU bubble arrangement under Article 4. The importance of these mechanisms is that they allow abatement to occur in relatively low cost locations, thereby potentially reducing the overall cost of meeting emission targets.

Emissions trading
Article 17 allows Annex B parties to participate in international emissions trading for the purpose of meeting their commitments under the protocol. Emissions of all gases from all sources and sinks included in the protocol may be traded. Furthermore, Articles 6 and 12, when read in conjunction with accounting rules under Articles 3.10, 3.11 and 3.12, permit parties to trade certified emission reductions generated by clean development mechanism projects and joint implementation projects. Credits are added to or subtracted from parties' assigned amounts.

Continued ➪

Box 1: ***The Kyoto Protocol*** *continued*

Clean development mechanism
The clean development mechanism, established in Article 12 of the protocol, aims to assist non-Annex B parties in achieving sustainable development and to help Annex B parties attain their target emission levels. Under the clean development mechanism Annex B parties would obtain certified emission reduction credits through financing emission reduction projects in non-Annex B countries. These projects must be undertaken voluntarily by both parties and must generate additional, long term emission reductions relative to those that would have occurred in the host country in the absence of the project.

A 'share of the proceeds' from clean development mechanism projects would be set aside to cover project administration costs and to assist developing countries that are particularly vulnerable to the adverse impacts of climate change in adapting to that change.

Sinks
The uptake of carbon from the atmosphere by sinks is an important component of the global climate system and is reflected in the Kyoto Protocol under Articles 3.3, 3.4 and 3.7.

Article 3.3
Article 3.3 permits Annex B parties to count net changes in greenhouse gas emissions resulting from afforestation, reforestation and deforestation activities established since 1990 in meeting their target commitments, provided these net emissions are are directly human induced and have taken place since 1990.

The IPCC has defined afforestation as the planting of new forests on land that has not historically contained forests. Reforestation is defined as the planting of new forests on land that historically has contained forests, but that has been converted to some other use. Deforestation is defined as the conversion of forested land to nonforested land.

Article 3.4
Article 3.4 provides a negotiating process to consider how and which additional sink activities in the agricultural soils, land use change and forestry categories can be included in commitment period emission accounting, provided these activities have taken place since 1990. Article 3.4 applies to sink activities not included in Article 3.3.

Article 3.7
The second sentence of Article 3.7 allows partries, such as Australia, for which the land use change and forestry sectors constituted a net source of greenhouse gas emissions in 1990 to include land use change in their 1990 emissions for the purpose of calculating their assigned amount.

able progress was made toward making the Bonn agreement operational, particularly in the area of emissions trading.

The implementation rules governing the Kyoto Protocol are of particular importance to New Zealand, where substantial sink credits are potentially available through forestry activities. These sink credits could become a valuable source of foreign income if they were sold on an international emission quota market.

It is against this background that ABARE was contracted to analyse a set of scenarios developed by the New Zealand Ministry of Agriculture and Forestry for its preratification assessment of the Kyoto Protocol. This study uses GTEM, ABARE's general equilibrium model of the world economy, to assess the impacts on New Zealand of issues associated with the design and implementation of the protocol as well as participation of Annex B countries in the protocol.

The protocol design issues that are examined in this study include the impact of the commitment period reserve, access to emission reductions under Article 3.4 of the protocol and the clean development mechanism (CDM). Various implementation issues are also considered, including the coverage of greenhouse gases, sources and sinks under the protocol, the role of agriculture in meeting the emission abatement task required under the protocol, restricting access in New Zealand to Article 3.3 sinks, revenue recycling, early action and the longer term impact of climate change policy. The issue of the participation of the former Soviet Union in the protocol is also examined in this study.

This study assesses the production, expenditure and trade impacts of the policy decisions underlying each scenario. No attempt to compare the overall costs of climate change itself with the costs of mitigation and adaptation to climate change is made in this study. Studies addressing the costs of climate change itself include Weyant et al. (1995) and Mendelsohn (1998).

It is important to note that although these scenarios cover a broad range of domestic and international climate change response policies, given the timing of their design, they do not reflect the outcomes negotiated at the resumption of COP6 in Bonn or the recent developments at COP7 in Marrakech. Nor do they reflect the recent decision of the US government not to ratify the protocol. However, these scenarios are of value in identifying and quantifying key issues affecting the New Zealand economy as a result of international climate change policy. For this reason the key findings from this study provide valuable information in assessing the implications for New Zealand of ratifying the protocol.

Subsequent to this analysis, ABARE has released two reports that incorporate these more recent developments. ABARE (2001), 'Economic outcomes of the Kyoto Protocol for New Zealand', analyses the implications of the Kyoto Protocol for New Zealand incorporating the decision of the US government not to ratify the protocol. Results of ABARE's most recent analysis, including the Bonn outcome and the US decision, are contained in ABARE conference paper 2001.28, 'The Kyoto Protocol: economic impacts under the terms of the Bonn agreement' (Jakeman et al. 2001), which is available on the ABARE website (www.abareconomics.com).

2. Analytical framework

The analysis of climate change policies in this study is based on scenario results from ABARE's global trade and environment model of the world economy, GTEM. GTEM is a dynamic general equilibrium model developed at ABARE to address policy issues with long term, global dimensions, such as climate change. It is derived from the MEGABARE model (ABARE 1996) and the GTAP model (Hertel 1997).

A detailed description of GTEM features can be found in Brown et al. (1999) and a full specification of the model can be viewed on ABARE's web page (www.abareconomics.com).

Anthropogenic greenhouse gas emissions arise from many activities throughout the economy. Therefore policies designed to constrain greenhouse gas emissions will influence almost every part of the economy. Models such as GTEM are able to capture the impacts of these policies on large numbers of economic variables, such as prices, output and trade and investment flows between regions.

Overview of the GTEM structure

Factors of production

Capital, land, labor and natural resources are the four primary factors of production. The capital stock in each region (country or group of countries) accumulates by investment less depreciation in each period. Both capital and labor are mobile between industries and, to a lesser extent, across regions through international capital flows and labor migration. Land is used only in agriculture and is fixed in each region.

GTEM explicitly models natural resource inputs as a factor of production in resource based sectors (coal mining, oil and gas extraction, other minerals, forestry and fishing). For example, the coal mining industry uses three factors of production — labor, capital and a natural resource (reserves of coal). The natural resource is a factor used solely in the production of resource based commodities and is not mobile between sectors or regions. Returns to the natural resource adjust to maintain its full employment. If, for example, the demand for coal were to decline, returns to the natural resource (its price) would fall, leading to a reduction in the supply price of coal.

The natural resource is a new feature of GTEM that has been adopted from the GTAP Version 4.0e database from which the GTEM database is derived. In the GTAP Version 4.0e database the initial value of returns to the natural resource is calibrated to imply a specific supply elasticity for each resource based sector. For a full discussion of the natural resource and assumed supply elasticities in GTAP, see McDougall, Elbehri and Truong (1998). The GTEM database is discussed in more detail below.

Population and labor supply for each region are determined endogenously (within the model) over time. GTEM contains an elaborate description of population dynamics, which captures the idea that as countries move along the economic development path, with increasing per person incomes, changes in fertility and mortality rates follow a well defined path. The model uses estimates of the dependence of fertility and mortality rates on income and an exogenously imposed migratory pattern to predict age and gender specific population changes.

Natural rate of unemployment

It is assumed that the imposition of carbon charges (or any other policy change) does not raise unemployment above the natural rate of unemployment for any economy. Any downward shifts in the demand for labor are assumed to be offset by reductions in real wages growth sufficient to prevent the emergence of unemployment above the natural rate. This assumption is often known as the 'full employment assumption' and its use is justified in cases when emission reductions are introduced progressively, allowing time for wages to adjust to new market conditions.

In practice, however, it could be expected that changes in patterns of production caused by the imposition of greenhouse gas emission constraints would lead to the emergence of some unemployment, especially if the emissions restrictions have negative impacts in sectors where the skills of the labor force are not easily transferable. Relaxing this assumption may therefore lead to increased estimates of the economic costs of greenhouse gas abatement policies.

Producer behavior

Producers in GTEM are assumed to operate in perfectly competitive markets using constant returns to scale technologies. Under these assumptions prices will be set to cover costs and GTEM industries earn normal profits at all times, with all returns paid to primary factors of production. Thus, changes in output prices are determined by changes in input prices of materials and primary factors.

National income, savings and consumption

In GTEM, a representative household in each region owns all factors of production and receives all payments made to the factors, all tax revenues and all net interregional income transfers. The representative household allocates its net income across private and public consumption and savings. National savings are assumed to move in line with national income.

Total consumption expenditure is calculated as the difference between current household income and savings, with the ratio of private consumption to government consumption assumed to be constant. Given total private consumption, the representative consumer maximises current period utility by choosing consumption levels for each consumption good.

Trade

A key feature of GTEM is that it models bilateral trade flows of all commodities between all regions. In GTEM an 'Armington' preference structure is adopted. This implies that a good produced in one region is an imperfect substitute for goods produced by the same industry in other regions (Armington 1969a,b). In other words, the same commodity from different sources can trade at different prices.

Consumers in a given region can substitute goods produced in that region with the same goods produced in other regions. For any given consumption activity, demand for a commodity is allocated between a domestic product and a composite imported product according to a CES (constant elasticity of substitution) function. The demand by a region for each composite imported commodity is then allocated between sources of imports according to a further CES function. Substitution between domestic and imported commodities and between imported commodities will depend on movements in relative prices and the specified elasticity of substitution — the Armington elasticity.

The Armington elasticities in GTEM vary between commodities and are derived from current literature and from some empirical work undertaken by Jomini et al. (1991) in the construction of the SALTER world trade model. As with all parameters in a global computable general equilibrium model, there is uncertainty about the appropriate size and relativities of the Armington elasticities for various commodities. These elasticities are important determinants of the model results in this report as they affect the estimated trade impacts on energy and energy intensive commodities resulting from Annex B emission abatement.

In equilibrium, the exports of a good from one region to the rest of world are equal to the import demand for that good in the remaining regions. GTEM does not require the current account to be in balance every year. It allows the capital account to move in a compensatory direction to maintain the balance of payments.

Goods are transported between regions by an international transport industry. The cost of international transport is added to the cost of imports to each country.

International capital mobility

Global investment equals global savings in GTEM. It is assumed that regional borrowers (investors) issue bonds to global savers at a risk free, global average rate of return. At the regional level, rates of return may differ to reflect country specific differences in the risk premium required by global savers. For example, global savers tend to place a higher risk premium on investing in developing countries in GTEM to reflect greater uncertainty of investing in these regions. The equilibrium rates of return in developing countries are therefore higher than in developed countries.

Investment demands, in turn, are determined by changes in regional real GDP and regional expected rates of return relative to expected global rates of return. Thus, changes in investment flows represent changes in demand from expansionary or contractionary effects (changes in real GDP) and expectation effects.

Any excess of investment over domestic savings for a given region causes an increase in net debt for the region. Borrowers service the debt at the global rate of return (interest rate).

Exchange rates

The exchange rate in GTEM is the price of converting local currency into global currency. It is the price that adjusts to keep the balance of payments in equilibrium. For example, if the imposition of a carbon charge leads to a significant decline in oil export earnings from a particular region this will, all things being equal, result in an exchange rate depreciation for that region. The depreciation in the exchange rate will improve the competitiveness of exporters and import competing producers in that region. Exports will increase and imports decline, restoring balance of payments equilibrium.

A change in the exchange rate will also influence international transfers associated with foreign debt or lending. For example, in GTEM, when a country that has borrowed from international capital markets experiences an exchange

rate depreciation its level of debt, denominated in foreign currency, will increase. The debt servicing requirement (interest paid) will increase in domestic currency terms. On the other hand, a country holding foreign assets through international lending will earn more interest income in domestic currency if its exchange rate depreciates.

Database

Regional and commodity coverage

The GTEM database is based on the GTAP 4.0e database, which contains 50 sectors and 45 regions and is based on 1995 production and trade data (expressed in US dollars). The GTAP database required substantial alteration for use in GTEM, particularly in the energy sector, and additional data (principally energy sector, emissions and population data) were collected.

The GTEM database contains 55 sectors and 45 regions. For this study, the database is aggregated to the 23 regions and 33 commodities that allow a detailed representation of Annex B countries and emission intensive industries, particularly in the agriculture sector (table 4).

The Russian Federation and the Ukraine is treated as an Annex B region in GTEM. It contains Annex B countries — Estonia, Latvia, Lithuania, the Russian Federation and the Ukraine — and non-Annex B countries such as Azerbaijan, Uzbekistan and Kazakhstan. However, the trade structure and output of the regions is dominated by the Annex B countries — the Annex B countries constitute 86 per cent of the former Soviet Union in real GDP terms. Of the Annex B countries, the Russian Federation and the Ukraine constitute 99 per cent in real GDP terms. This means that emission abatement opportunities in the former Soviet Union largely reflect abatement opportunities in the Russian Federation and the Ukraine. The calculation of Kyoto emission targets includes only emissions in the Annex B countries of the former Soviet Union.

The emission targets for the aggregated Annex B regions are the summation of individual country commitments under the Kyoto Protocol weighted by greenhouse gas emissions of carbon dioxide, methane and nitrous oxide in 1990, expressed in carbon dioxide equivalents.

Greenhouse gas emissions in GTEM

GTEM models emissions of three greenhouse gases — carbon dioxide, methane and nitrous oxide. In Annex B regions, carbon dioxide, methane and nitrous oxide account for around 99 per cent of anthropogenic greenhouse gas emis-

sions on a carbon dioxide equivalent basis, excluding land clearing (United Nations 1999).

For all countries except Australia and New Zealand, emissions data for 1995 are based on International Energy Agency (1998), countries' National Communications to the United Nations Framework Convention on Climate Change (UNFCCC Greenhouse Gas Inventory Database 2000) and ABARE estimates. Emissions data for Australia and New Zealand derive from their

4 GTEM regions and commodities used in this study

Regions	**Commodities**
Australia	Coal
United States	Oil
Canada	Gas
Japan	Petroleum and coal products
European Union	Electricity
Russian Federation and Ukraine	Iron and steel
Eastern Europe	Nonferrous metals
New Zealand	Chemicals, rubber and plastic
EFTA **a**	Clothing
Korea	Meat products
Indonesia	Dairy products
China	Food
India	Pulp, paper and publishing
Rest of Asia	Other wood products
Mexico	Minerals
Argentina	Nonmetallic minerals
Brazil	Light manufacturing
Chile	Other manufacturing
Uruguay	Construction
Rest of South America	Trade and transport
Middle East	Other services
Northern Africa	Public services
Rest of the world	Private services
	Rice
	Wheat
	Other cereal grains
	Crops
	Forestry
	Fisheries
	Livestock for meat
	Other animal products
	Dairy cattle
	Wool

a European Free Trade Area: comprises Switzerland, Norway and Iceland.

respective 1998 National Greenhouse Gas Inventories (Australian Greenhouse Office 2000; New Zealand Ministry for the Environment 2000a).

Emissions of methane and nitrous oxide are represented in GTEM in carbon dioxide equivalents. The carbon dioxide equivalent is derived by multiplying the emissions by the appropriate global warming potential, a measure of the relative radiative forcing of different greenhouse gases. The global warming potential values are 1, 21 and 310 for carbon dioxide, methane and nitrous oxide respectively over a one hundred year time horizon (IPCC 1996). At current atmospheric concentrations, an additional tonne of nitrous oxide in the atmosphere, for example, is considered to be 310 times more potent in terms of radiative forcing than an additional tonne of carbon dioxide, over a one hundred year time horizon. In this report all greenhouse gas emissions are expressed as carbon dioxide equivalents.

Carbon dioxide

There are two main categories of carbon dioxide emissions — those from fossil fuel combustion and those from noncombustion sources.

Fossil fuels emit carbon dioxide when converted into energy. The three fossil fuels that are modeled in GTEM are coal, oil and natural gas. However, because oil is largely transformed into petroleum and other products, the carbon dioxide emissions that are embodied in oil are attributed to the consumption of petroleum products.

Carbon dioxide emissions from other, noncombustion industrial processes are also represented in GTEM. These comprise fugitive emissions from oil and natural gas systems, emissions from aluminium production and emissions from the manufacture of cement.

Methane and nitrous oxide

Livestock are the most significant source of methane emissions. Other sources of methane are fugitive emissions from coal mining, oil extraction and natural gas systems and emissions from paddy rice cultivation.

Livestock waste and the application of nitrogenous fertilisers in agricultural industries are significant sources of nitrous oxide emissions. The transport and chemicals industries are other important sources.

Sinks

A preliminary representation of carbon sequestration in Annex B countries is included in the modeling in this report: work is under way to improve this representation.

Limitations of emissions coverage in GTEM

Sources of the gases that are not represented in GTEM are outlined below. The remaining gases — hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride — are not currently modeled.

Greenhouse gas emissions from burning savannas and agricultural residues are not included as data are not widely available.

Methane emissions from the disposal of solid waste, wastewater handling and waste incineration are not accounted for in this analysis. At present GTEM does not explicitly include a waste industry.

Small proportions of methane and nitrous oxide emissions are attributable to various industrial processes and combustion activities other than those modeled in GTEM.

Emission reduction responses

In modeling the impact of greenhouse gas abatement policies in GTEM, emission reductions are available from reductions in combustion related carbon dioxide emissions through energy efficiency improvements and fuel switching, and from reductions in noncombustion sources through adoption of new technologies and management practices. Other things being equal, reduced activity levels in main emitting sectors will also lead to emission reductions.

Emission reduction responses in the electricity and iron and steel industries are modeled using the technology bundle approach. These industries are able to substitute between different production technologies, which each contain fixed but different input mixes. Electricity can be generated from coal, petroleum, gas, nuclear, hydroelectric and renewable based technologies, while iron and steel can be produced using blast furnace or electric arc technologies. All other industries can substitute between fuels, which include coal, gas, petroleum and electricity and can also substitute fuels for primary factors, which include land, labor, capital and natural resources.

Where industries are able to reduce emissions without reducing inputs to the production process, GTEM uses emission response functions to model emissions in these industries. The emission response functions apply to noncombustion carbon dioxide, methane and nitrous oxide from the majority of emitting industries but not to the combustion of fossil fuels. The magnitude of an emission reduction response is determined by the size of the carbon charge and, for methane emissions from coal mining, livestock and natural gas production, energy prices. Captured methane can be used to generate electricity or be

pumped directly into a natural gas pipeline. Although the carbon charge must reach certain thresholds before efficiency improvements are available, they are then assumed to be implemented at no additional cost to the industry.

The emission response data for most industries were largely taken from Gibbs (1998) and Cheminfo (1998), with additional information on methane emission reductions in paddy rice production and the ability to reduce fertiliser use taken from Watson, Zingowera and Moss (1996). Gibbs (1998) and Cheminfo (1998) provide estimates based on industry studies in the United States and Canada. Because data are limited, it is assumed that the abatement options are available for each noncombustion carbon dioxide gas by source, with the exception of livestock, are the same across each Annex B region. The emission response coefficients for all industries except the livestock industry are shown in table 5.

For this study, the emission response function for methane emissions from the livestock sector was revised to account for differing abatement possibilities in enteric fermentation and manure management. The revised function was weighted according to the proportion of methane emissions from enteric fermentation and manure in each Annex B country except New Zealand and Australia. Data on enteric manure management for this revision were taken from the Second Assessment Report of the Intergovernmental Panel on Climate

5 *Emission reduction coefficients in nonlivestock industries*

Industry	Greenhouse gas	Percentage emission reduction for a carbon equivalent charge of:					
		US$10/t carbon equiv.	US$50/t carbon equiv.	US$100/t carbon equiv.	US$150/t carbon equiv.	US$200/t carbon. equiv.	US$500/t carbon equiv.
		%	%	%	%	%	%
Nonmetallic minerals (lime production) **a**	CO_2	0	10	10	10	10	80
Nonferrous metals (aluminium) **a**	CO_2	5	25	25	25	25	25
Coal **b**	Methane	19	37	37	37	37	37
Oil **b**	Methane	15	18	24	25	25	25
Natural gas **b**	Methane	15	18	24	25	25	25
Paddy rice **c**	Methane	10	50	50	50	50	50
Chemicals, rubber and plastics **a**	Nitrous oxide	95	95	95	95	95	95
Fertiliser use (all crops) **c**	Nitrous oxide	20	40	70	72	73	75

a Cheminfo (1998). **b** Gibbs (1998). **c** Watson, Zingowera and Moss (1996).

6 *Methane emission reduction coefficients in the livestock industry*

Region	Percentage emission reduction for a carbon equivalent charge of:					
	US$10/t carbon equiv.	**US$50/t carbon equiv.**	**US$100/t carbon equiv.**	**US$150/t carbon equiv.**	**US$200/t carbon. equiv.**	**US$500/t carbon equiv.**
	%	%	%	%	%	%
Australia	3.0	11.0	16.0	16.8	17.3	17.3
Japan	6.8	24.9	36.3	38.0	39.1	39.1
Canada	6.5	23.8	34.6	36.2	37.3	37.3
United States	7.4	27.0	39.2	41.1	42.3	42.3
European Union	6.9	25.1	36.6	38.3	39.4	39.4
EFTA **a**	6.1	22.3	32.5	34.0	35.0	35.0
Eastern Europe	7.3	26.8	38.9	40.8	42.0	42.0
Russian Federation and Ukraine	5.8	21.3	31.1	32.5	33.5	33.5
New Zealand						
– dairy **b**	3.0	11.0	16.0	16.8	17.3	17.3
– beef and sheep **b**	1.7	6.4	9.3	9.7	10.0	10.0

a European Free Trade Area: comprises Switzerland, Norway and Iceland. **b** Sourced by the New Zealand Ministry of Agriculture and Forestry.
Source: Gibbs (1998).

Change (IPCC 1996). For New Zealand, methane emission response parameters for dairy and beef cattle and sheep were supplied by the New Zealand Ministry of Agriculture and Forestry. The revised emission response coefficients for the livestock industry in each region are shown in table 6.

3. Reference case

The GTEM reference case provides a representation of the world economy over the period 1996–2020 in the absence of policies designed to reduce greenhouse gas emissions. Comparing the projections from a policy scenario with results from the reference case allows the effects of implementing a policy change under the Kyoto Protocol to be isolated.

The GTEM reference case incorporates the impacts of ongoing and future energy policy changes unrelated to climate change issues, such as the effect of electricity market deregulation on the fuel mix in electricity generation. The shares of electricity generated by each electricity technology are exogenously imposed in the GTEM reference case. The shares are based on International Energy Agency projections (IEA 1999).

In developing the GTEM reference case, historical data for real GDP are included from 1996 to 2000. Real GDP projections in GTEM beyond 2000 are based on ABARE (2000) and IMF (2000) forecasts and on convergence theory, under which it is assumed that per worker real GDP converges toward that of the United States after 2005. The New Zealand real GDP data used in this report were supplied by the New Zealand Ministry of Agriculture and Forestry.

The GTEM Annex B reference case includes estimates of carbon sequestration under Articles 3.3 and 3.4 of the Kyoto Protocol. Given the uncertainty surrounding the interpretation and definition of many clauses in Articles 3.3 and 3.4, preliminary estimates of sequestration are used here. The estimates for sequestration under Article 3.3 are from Annex B party submissions to the Subsidiary Body for Scientific and Technological Advice of the UNFCCC (www.unfccc.int/resource/docs/2000/sbsta/09a1.pdf). The estimate for the Russian Federation and the Ukraine is taken from Schlamadinger and Karjalainen (2000) while the estimate for New Zealand is provided by the New Zealand Ministry of Agriculture and Forestry.

In modeling reference case sinks under Article 3.4, it is assumed that carbon sequestration under Article 3.4 is determined as a percentage of each Annex B party's assigned amount under the Kyoto Protocol. The GTEM assigned amount accounts for all carbon dioxide, methane and nitrous oxide emissions listed in the protocol. Sequestration under Article 3.4 is set at 3 per cent of the GTEM assigned amount for each Annex B party. For New Zealand, however, the estimate of carbon sequestration under Article 3.4 was assumed to be zero

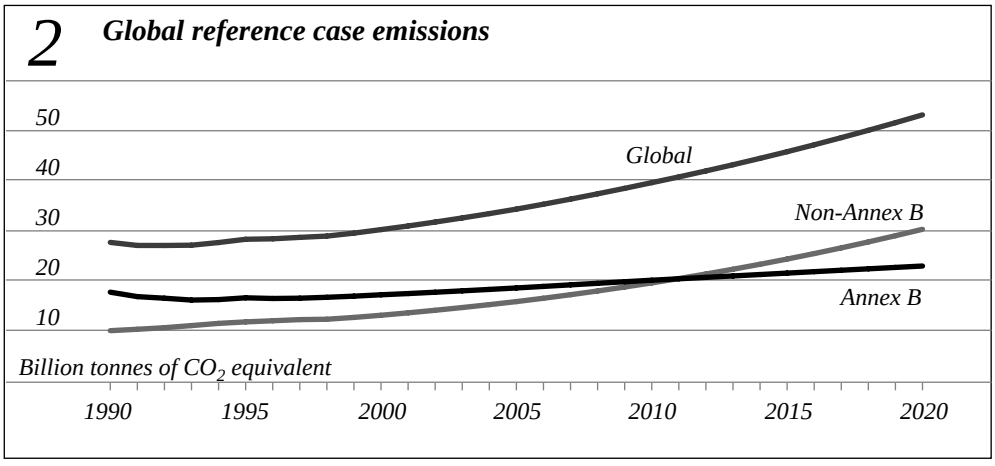
based on New Zealand Ministry of Agriculture and Forestry estimates. The estimates used in this analysis are based on accounting rules proposed in climate change negotiations at the Hague.

Carbon sequestration in GTEM is modeled as a net addition to or subtraction from each country's assigned amount, rather than as a result of, for example, production in the forestry industry. For this reason the value of carbon sequestered by each sector does not influence profitability and growth in that sector.

Global emissions projections

Global emissions of the three major greenhouse gases (carbon dioxide, methane and nitrous oxide) are projected to rise from 28 billion tonnes of carbon dioxide equivalent in 1990 to 39 billion tonnes by 2010 (figure 2). The growth in global emissions is driven largely by high emissions growth in non-Annex B countries, which are projected to overtake emissions from Annex B sources by 2011. The share of emissions from non-Annex B countries in global emissions is projected to increase from around 40 per cent in 1990 to 49 per cent in 2010 and 57 per cent at 2020.

The primary determinants of emissions growth are the growth in economic activity (real GDP), changes in the emission intensity of output (measured as greenhouse gas emissions per dollar of output), and the assumed level of carbon sinks. All things being equal, reductions in emission intensity reduce the emissions generated from increased economic activity. Changes in emission intensity over the reference case are caused by changes in the structure of the economy, in energy and process efficiency and in energy sources, in particular the fuel mix in electricity generation.



The projected average annual changes in emissions, real GDP and the emissions intensity of output over the reference case are shown in table 7. Emissions in the Russian Federation, the Ukraine and eastern Europe are projected to fall over the reference case. The economic growth rates assumed for the Russian Federation, the Ukraine and eastern Europe over the projection period are not sufficient to offset the fall in emissions between 1990 and 1996 resulting from economic restructuring. It should be noted that uncertainty about the medium term economic development in these regions means that the emission projections are also subject to a high degree of uncertainty.

Reference case emissions in the European Union and Japan are projected to rise by less than 1 per cent a year between 1990 and 2010. In the European Union, emissions fell by around 2 per cent a year between 1990 and 1998 and low emissions growth is projected thereafter. The decline in emissions between 1990 and 1998 was mainly a result of the substitution of gas for coal in electricity generation in the United Kingdom and economic restructuring in east Germany (Jotzo et al. 2000). In Japan, projected real GDP growth between 1990 and 2010 is lower than the Annex B average, leading to relatively low emissions growth.

The highest rates of emissions growth are projected to be in Canada, the United States and Australia. An important factor for high emissions growth in these countries is the high assumed rates of real GDP growth.

7 Projected average annual change in emissions, real GDP and emission intensity of output, 1990–2010 – reference case

	Carbon dioxide equivalent emissions	**Real GDP**	**Emission intensity of output [a]**
	%	%	%
Australia	1.6	3.6	–2.0
United States	1.8	3.0	–1.2
Canada	1.9	3.0	–1.1
Japan	0.9	1.8	–0.9
European Union	0.5	2.5	–2.0
Russian Federation and Ukraine	–1.3	–0.1	–1.2
Eastern Europe	–0.2	2.4	–2.5
New Zealand	1.2	2.7	–1.5
EFTA [b]	1.3	2.5	–1.1
Annex B	0.6	2.5	–1.8
Non-Annex B	3.4	5.1	–1.6
Global	1.8	3.0	–1.2

a Excluding emissions from land use change and forestry. **b** European Free Trade Area: comprises Switzerland, Norway and Iceland.

New Zealand reference case projections

Macroeconomic projections

The GTEM reference case results are driven by projections of real GDP for each country. As mentioned earlier, these projections are based on ABARE (2000) and IMF (2000) forecasts and on convergence theory, under which it is assumed that per worker real GDP converges toward that of the United States after 2005. However, the New Zealand real GDP data used in this report were supplied by the New Zealand Ministry of Agriculture and Forestry. The rate of projected real GDP growth assumed for New Zealand over the reference case is lower than for all other OECD countries except Japan.

It should be noted that GTEM is a long run sectoral model of the world economy. It is not designed to capture the detailed interaction of macroeconomic variables over the business cycle. However, the GTEM reference case used in this analysis does display the following characteristics of New Zealand's recent macroeconomic history:

- growth in the quantity of domestic investment exceeds growth in the quantity of domestic savings, leading to an accumulation of foreign debt;
- the value of exports in New Zealand grows with the value of imports;
- the current account continues to deteriorate owing to the large interest payments New Zealand must make on its foreign debt;
- these interest payments cause real GDP to grow more rapidly than real GNP in New Zealand.

The reference case projections for key macroeconomic variables in New Zealand are shown in table 8. These variables include real GDP, real GNP, the real exchange rate, the quantity of exports, imports, savings and investment and the terms of trade.

It should be noted that in this report, contrary to regular GTEM protocol, an appreciation of the real exchange rate is denoted by a positive change in the real exchange rate as reported in the results tables.

8 Projected average annual change in New Zealand macroeconomic indicators, 1995–2010 – reference case

	%
GDP	2.6
GNP	1.7
Exchange rate	–0.1
Exports	2.5
Imports	2.8
Terms of trade	0.3
Savings	1.7
Investment	5.8

Emission projections

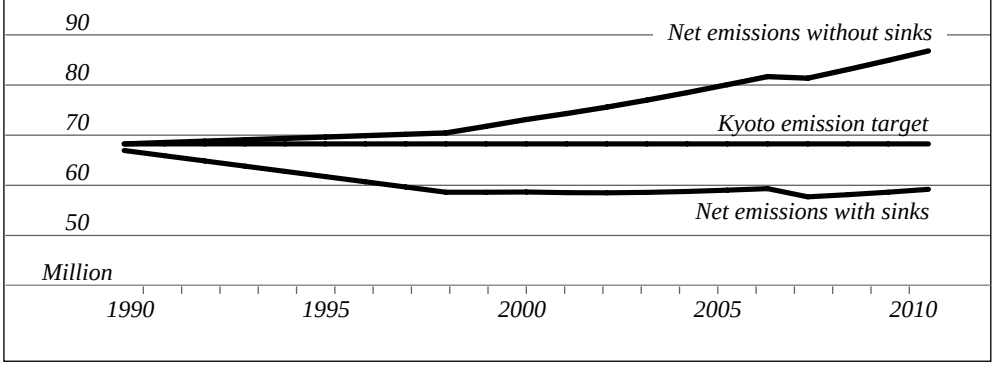
Under the Kyoto Protocol, New Zealand is required to maintain its net greenhouse gas emissions at 1990 levels over the first commitment period, 2008–12. Over the reference case New Zealand's net greenhouse gas emissions, excluding carbon sequestered by forestry activities, are projected to grow from 68.3 million tonnes of carbon dioxide equivalent in 1990 to 86.8 million tonnes at 2010 (figure 3). However, carbon sequestration by forest sinks under Article 3.3 is an important element in New Zealand's reference case emissions profile.

The replacement of grasslands, shrublands and agricultural land with commercial and farm forestry plantations in New Zealand since 1990 is projected to generate 138 million tonnes of carbon dioxide equivalent sinks under Article 3.3 between 2008 and 2012 (New Zealand Ministry for the Environment 2000b). These carbon sinks, which translate into a carbon sequestration of 27.6 million tonnes of carbon dioxide equivalent in each year of the first commitment period, are projected to reduce New Zealand's net greenhouse gas emission to 59.2 million tonnes of carbon dioxide equivalent at 2010.

The emissions coverage in GTEM accounts for almost 96 per cent of greenhouse gas emissions in New Zealand (table 9). GTEM does not include emissions from waste, emissions from agricultural residues or methane and most nitrous oxide emissions from combustion and some industrial processes. However, nitrous oxide emissions from combustion in the transport sector are included in GTEM.

In 1998 the livestock industry, which emits mostly methane, accounted for over half of New Zealand's greenhouse gas emissions (table 9). Over the reference case, emissions from dairy cattle are projected to grow rapidly, emis-

3 *New Zealand reference case emissions*



sions from livestock for meat production are projected to increase slightly and emissions from wool production are projected to fall marginally. The differences in these emission growth rates reflect the current movement of livestock producers toward dairy production, which is assumed to continue over the period to 2010. Despite the projected growth in emissions from livestock over the reference case, the share of livestock emissions in total greenhouse gas emissions is projected to fall between 1998 and 2010 (table 10). This reflects more rapid projected emissions growth elsewhere in the economy, notably in the transport and electricity sectors.

Emissions from the trade and transport sector are projected to increase from 6.4 million tonnes of carbon dioxide equivalent to 8.2 million tonnes, growing as a share of national emissions over the period (table 10).

Emissions from the chemicals, rubber and plastic sector are projected to fall from 2.4 million tonnes of carbon dioxide equivalent to 0.7 million tonnes

9 *GTEM coverage of New Zealand emissions, 1998* **a**

	Emissions	**Share of total emissions**
	kt CO_2 equiv.	%
Livestock	39 974	54.4
Transport and trade	6 381	8.7
Private household emissions	5 825	7.9
Electricity production	4 044	5.5
Construction and services	2 747	3.7
Other primary production	2 477	3.4
Metals production	2 423	3.3
Chemicals production	2 366	3.2
Fossil fuel production	2 346	3.2
Minerals production	1 048	1.4
Manufacturing, textiles and processing	821	1.1
GTEM coverage total	70 451	95.9
Emissions omitted from GTEM coverage		
Other energy sector emissions	163	0.2
Other industrial processes – including perfluorocarbons and sulfur hexafluoride	96	0.1
Other agriculture – agricultural residues	3	0.0
Waste	2 785	3.8
NGGI total	73 498	100.0

a Includes CO_2, CH_4 and N_2O emissions.
Source: New Zealand Ministry for the Environment (2000a).

10 ***Change in New Zealand sectoral emissions over the reference case, 1998–2010*** **a**

	1998	2010
	Mt CO_2 equiv.	Mt CO_2 equiv.
Livestock	40.0	46.0
Transport and trade	6.4	8.2
Private household emissions	5.8	7.1
Electricity production	4.0	8.1
Construction and services	2.7	4.1
Other primary production	2.5	3.7
Metals production	2.4	3.3
Chemicals production	2.4	0.7
Fossil fuel production	2.3	2.9
Minerals production	1.0	1.6
Manufacturing, textiles and processing	0.8	0.9
Total	70.5	86.8

a Includes CO_2, CH_4 and N_2O emissions.
Source: New Zealand Ministry for the Environment (2000a).

between 1998 and 2010 as a result of the assumed closure of New Zealand's methanol plants in 2007.

Electricity generation contributed just under 6 per cent of New Zealand's emissions in 1998 (table 10). In contrast, almost a third of total greenhouse gas emissions in Australia in 1998 derived from electricity generation. About 75 per cent of electricity in New Zealand was generated using hydroelectric technology, which produces virtually no greenhouse gas emissions.

11 ***Technology shares in New Zealand electricity generation, 1995 and 2010 – reference case***

	1995	2010
	%	%
Coal	1.9	8.2
Oil	0.0	0.1
Gas	13.5	22.4
Nuclear	0.0	0.0
Hydro	82.8	68.6
Other renewables	1.7	0.8

Source: New Zealand Ministry of Agriculture and Forestry.

Over the reference case, emissions from electricity generation are projected to grow more rapidly than in any other sectors as limited expansion possibilities in hydroelectricity generation are projected to lead to greater use of relatively emission intensive coal and gas fired electricity plants (table 11).

4. Modeling emission abatement policies

The policy scenarios presented in this study assume that signatory countries to the Kyoto Protocol reduce their national emissions from 2008 and reach their annualised Kyoto target in 2010. The exception is scenario 11a, where it is assumed that New Zealand begins reducing national emissions from 2003. The model specification requires that a particular year (2010) be defined as the time at which the Kyoto targets are met. In practice, countries must meet their emissions target over an average of the years 2008–12, the first commitment period under the Kyoto Protocol.

It is assumed that in achieving emission reductions, governments adopt policy instruments that impose the smallest possible cost on their economies. A discussion of efficient approaches to reducing carbon dioxide emissions within a country can be found in Fisher et al. (1996). If least cost approaches are not adopted, the estimated economic costs of implementing the Kyoto Protocol would be higher than those reported here.

In GTEM, least cost modeling of emission abatement involves imposing a 'charge' on greenhouse gas emissions in each period for which emission restrictions apply. The charge represents the broad class of least cost economic instruments that could be used by governments to reduce emissions (see Fisher et al. 1996). The charge could represent a domestic emissions trading scheme or a uniform carbon charge applied in a particular region. The imposition of this charge raises the costs associated with emission producing activities and encourages a shift of resources into less emission intensive technologies or activities. These shifts will occur until the marginal cost of further abatement equals the carbon charge.

Unless otherwise specified, any revenue raised from the domestic application of the carbon charge or from sales of emission quota on the emission quota market is assumed to be returned to the economy in a lump sum fashion, thus having a neutral effect on the economy. In practice, changing the way in which revenue is returned to the economy can alter the implications of emission abatement. For example, some analysts have shown that using the revenue from a carbon tax to reduce government budget deficits or to replace highly inefficient taxes can confer benefits on an economy (see, for example, McDougall and Dixon 1996). However, such approaches to the treatment of carbon charge revenue do not permit the impacts of emission abatement to be separated from

the impacts of taxation or budgetary reforms and therefore can provide a distorted picture of the impacts of emission abatement on economies.

In GTEM it is also assumed that there is perfect compliance with the abatement policies analysed and compliance is achieved at zero cost. Similarly, it is assumed that emission monitoring is perfect and costless also and that carbon charges are applied at the same point that emissions are generated (point taxation). This implies that complete accounting information on actual emissions is available to the regulating authority, and that there are no administrative costs associated with the abatement policies assessed.

The assumption of point taxation is important in the context of greenhouse gas emissions from noncombustion sources. For example, in practice, it may be difficult to estimate methane and nitrous oxide emissions from the livestock sector as the level of emissions depends on herd size, composition (by breed and age), feed quality, environment and management practices. Hinchy, Fisher and Graham (1998) discuss in detail the advantages of point taxation over taxation applied elsewhere in the production or distribution chain (nonpoint taxation) in terms of achieving least cost abatement but note that nonpoint taxation is often easier to enforce. To continue the example of livestock production, taxation could occur at some point away from the emission source, such as at the wholesale or retail sale level for meat and milk, where these products would be taxed according to approximate average embodied emissions. Nonpoint taxation would result in a move away from the least cost approach to emission abatement, raising the carbon charge projected by GTEM.

International emissions trading

The cost of meeting Annex B emission abatement commitments depends to a large degree on access to the Kyoto mechanisms and to carbon sinks. Unrestricted international emissions trading allows more abatement to be undertaken in countries where the marginal cost of abatement (at the given quota allocation) is lowest. There will be no incentive for further trade in quotas once the marginal abatement cost from each emissions source is equal to the price of the quota. At this point, the cost of Annex B abatement will be minimised, ignoring for simplicity the effect of transaction costs. It is assumed that no sector is exempt from being required to hold emission quotas equal to its emissions.

In GTEM, modeling international emissions trading requires the aggregate emissions of participating regions to be constrained to their emission reduction commitments under the Kyoto Protocol. The model determines a uniform carbon charge across Annex B regions (equivalent to the price of an interna-

tionally traded emission quota) sufficient to meet the aggregate emission target. The individual Kyoto commitments represent an initial allocation of obligations, or emission quotas, among the participating regions. These can be traded between regions in a perfectly competitive market. Income from (payment for) the sale (purchase) of emission quota is classified as foreign income transfers and added to (subtracted from) real GNP.

Commitment period reserve

Restrictions on emission quota sales limit the extent to which abatement is shifted from countries with high marginal abatement costs (at a given quota allocation), such as Japan, to countries where the marginal abatement cost is lower, such as the Russian Federation and the Ukraine. As a result, marginal abatement costs will not be equalised across regions and the total cost of abatement will not be minimised.

A current proposal is to limit the sale of emission quota by requiring each country to hold a minimum amount of emission quota over the commitment period, referred to as the commitment period reserve. For each Annex B country, the commitment period reserve is equal to a percentage of its assigned amount (rule A) or of its most recently reviewed national inventory (rule B), whichever is lower.

Rule A would apply to countries with emissions above their assigned amount over the commitment period, while rule B would apply to countries (such as the Russian Federation and the Ukraine) with latest inventory levels below their assigned amount over the commitment period. In this analysis the most recent emissions inventory is assumed to be reference case emissions at 2007.

A reduction in potential sales on world markets under a commitment period reserve leads to an equivalent increase in the amount of emission quota in the domestic markets of selling countries relative to unrestricted trade. As such, the marginal cost of abatement in quota selling countries under a commitment period reserve is lower than under unrestricted trade. Because the world supply of quota has been restricted, the world price of quota is increased relative to unrestricted trade. This process drives a wedge between the marginal cost of abatement in selling countries and the price of quota traded internationally. The difference between these prices is the economic rent associated with the right to sell quota in international markets. It is assumed that this rent is retained by the selling country (that is, that the quota price equals the marginal cost of abatement in countries purchasing quota).

Clean development mechanism

The policy analysis presented in this study contains an illustrative representation of clean development mechanism (CDM) projects in forestry and technology transfer in thermal electricity generation. Projects in these sectors offer potentially significant abatement opportunities at a relatively low cost (World Bank 2000; Zou and Junfeng 2000; Seroa da Motta, Ferraz and Young 2000).

It is assumed that certified emission reductions (CERs) generated from the CDM projects are perfectly substitutable with Annex B emission quotas (assigned amount units) in an Annex B emissions trading scheme — in line with Article 3.12 of the Kyoto Protocol. As a consequence, the price of a CER (including allowance for the adaptation and administrative levies) is the same as the international quota price. It is further assumed that the net revenue from the sale of CERs is shared equally between the non-Annex B hosts and Annex B investors.

To undertake a comprehensive analysis of the economic impacts of technology transfer in the CDM, large amounts of project specific data would be required.

12 *Certified emission reductions (CERs) from forestry and technology transfer in electricity generation*

	Forestry [a]		**Technology transfer** [b]		**Total**	
	2010	**2001–10**	**2010**	**2001–10**	**2010**	**2001–10**
	Mt CO_2 equiv.	2Mt CO_2 equiv.	Mt CO_2 equiv.	Mt CO_2 equiv.	Mt CO_2 equiv.	Mt CO_2 equiv.
Korea	0.1	0.8	1.6	9.4	1.8	10.2
Indonesia	0.3	1.6	2.6	12.4	2.9	14.0
China	4.1	22.4	25.6	124.7	29.7	147.1
India	0.7	3.8	15.9	80.0	16.5	83.8
Rest of Asia	0.3	1.8	6.8	32.7	7.1	34.5
Mexico	0.0	0.1	3.5	17.6	3.6	17.7
Argentina	0.3	1.5	0.8	4.4	1.1	5.8
Brazil	1.9	10.5	0.5	2.5	2.4	13.0
Chile	1.0	5.6	0.4	1.9	1.4	7.5
Uruguay	0.4	2.3	0.0	0.0	0.4	2.4
Rest of Latin America	0.7	3.6	2.1	10.2	2.7	13.9
Middle East	0.0	0.2	8.5	44.9	8.5	45.1
North Africa	0.3	1.8	1.9	10.0	2.2	11.8
Rest of non-Annex B	0.9	4.7	10.7	51.6	11.6	56.3
Total	11.0	60.7	81.0	402.2	92.1	462.9

a CERs generated from an additional 10 per cent of sequestration from reference case plantings in non-AnnexB countries. **b** CERs generated from a 2.5 per cent efficiency improvement in thermal electricity generation in non-Annex B regions.

In this illustrative analysis it is assumed that developing countries catch up 10 per cent of the efficiency gap between non-OECD and OECD countries, in half the current stock of thermal power generation capacity (CERs estimated are presented in table 9). This is equivalent to a 2.5 per cent efficiency improvement in thermal electricity generation, implemented incrementally, with the total improvement met by 2010. Refer to Polidano et al. (2000) for a detailed exposition of the technology transfer analysis.

Forestry projects allowed under the CDM must deliver emission reductions that are additional to abatement that would occur in the absence of the certified project activity (Article 12.5c). With the rules governing the use of forestry projects in CDM undecided, it is assumed here that each non-Annex B region is able to generate CERs equal to an additional 10 per cent of carbon sequestration by reference case plantings of commercial forests (table 12).

Projections of carbon sequestration from reference case plantings are based on a study on the global outlook for plantations by ABARE and Jaako Pöyry Consulting (1999). The study focused on the change in supply of timber from plantation forests and hence the estimates do not incorporate sequestration from afforestation and reforestation activities for reasons other than timber supply. The assessment of forestry credits for sinks projects in the CDM presented in this study should be regarded as illustrative only because of uncertainty about additional requirements. It is assumed that any projected increase in the area of plantations occurs on land that is not currently forested and the composition of tree species in each forest is assumed to be constant over the reference case.

Increasing the scope of CDM projects to allow the generation of CERs from forestry projects gives regions with low dependence on thermal energy, such as south American countries, a greater opportunity to participate in CDM activities (table 12).

However, some regions that are not dependent on thermal energy sources, such as Africa, are also projected to have limited scope for CDM projects from forestry. Emissions from deforestation in Africa between 1990 and 1995 are estimated to have been 2.7 billion tonnes of carbon dioxide

13 Estimated average annual carbon dioxide equivalent emissions from deforestation, 1990–95 **a**

	Emissions
	Mt CO_2 equiv.
China	59
India	0
Korea, Rep. Of	6.8
Rest of ASEAN	710
Indonesia	917
Middle East	20
Africa	2 674
South America	4 909
Rest of non-Annex B	876
Total	10 167

a Estimates are based on deforestation estimates from FAO (1999). The age of trees on cleared land is assumed to be the average rotation length of each species.

equivalent a year (table 13). Including CDM projects that reduced deforestation would provide Africa with more opportunities to participate in CDM activities.

CDM projects that reduce deforestation are not currently modeled in GTEM because any agreement on sinks in the CDM is likely (as the Bonn decision confirms) to exclude deforestation.

Article 3.3 and 3.4 sinks

The sequestration of carbon from the atmosphere by carbon sinks such as forests is an important element of the global climate system. As human activities can influence the volume of carbon sequestered by these sinks, the Kyoto Protocol contains two articles, Article 3.3 and Article 3.4, that aim to make countries in Annex B accountable for the changes in carbon sequestered by their carbon sinks over the commitment period. Article 3.3 applies to carbon sequestered through the intentional afforestation and reforestation of previously unforested land and the deforestation of previously forested land since 1990. At Bonn, it was agreed that Article 3.4 would apply to carbon sequestered as a result of changes to the management of forests, crop land and grazing land and the revegetation of degraded land since 1990.

In this pre-Bonn analysis, the following represent the estimated levels of carbon sequestered by activities under Articles 3.3 and 3.4.

14 Carbon sequestration under Articles 3.3 and 3.4 in each Annex B country at 2010

	Article 3.3 **a**	**Article 3.4** **b**
	Mt CO_2 equiv.	Mt CO_2 equiv.
New Zealand	27.6 **b**	0.0
Australia	–24.9	13.4
United States	–26.4	70.0
Canada	–16.1	15.0
Japan	–2.7	15.0
European Union	5.0	115.2
Russian Federation and Ukraine	–44.5 **c**	120.8
Eastern Europe	0.0	37.8
EFTA **d**	0.0	3.1
Total	–82	390.1

a From Annex B party submissions to the SBSTA of the UNFCCC unless otherwise specified. **b** Provided by New Zealand Ministry of Agriculture. **c** From Schlamadinger and Karjalainen (2000). **d** European Free Trade Area: comprises Switzerland, Norway and Iceland.

For Annex B as a whole, activities under Article 3.3 are projected to result in a net emission of greenhouse gases (table 14). For all Annex B regions except New Zealand, eastern Europe, EFTA and the European Union, activities under Article 3.3 are projected to result in a net source of greenhouse gas emissions in the first commitment period. These net emissions may be overstated in countries that have planted forests since 1990 that are due for harvesting during the first commitment period. Under Article 3.3 only the changes in carbon sequestered by these forests over the commitment period are to be recorded by countries when calculating their emission levels. Thus, Article 3.3 forests harvested during the commitment period may be recorded as a net source of greenhouse gas emissions, when in fact they have been a net greenhouse gas sink in the years between 1990 and the commencement of the first commitment period. While the outcomes reached at the COP6 negotiations in Bonn agreed that this anomaly would be corrected for the first commitment period (United Nations 2001), results presented in this study do not correct for this anomaly.

Article 3.4 activities are projected to result in a significant net emission reduction for Annex B as a whole. Accounting for Article 3.4 sinks in national greenhouse gas emissions is estimated to have little effect on net greenhouse gas emissions in New Zealand and EFTA but is projected to have more noticeable effects in the Russian Federation and the Ukraine and in the European Union. Including Article 3.4 sinks in emissions accounting under the protocol is likely to affect both the carbon charge and the relative abatement costs in each Annex B country. For these reasons, even countries without significant Article 3.4 sinks are likely to be affected by the inclusion of Article 3.4 in emissions accounting under the protocol.

5. Economic impacts of emission abatement policies

In the scenarios reported here, the economic impacts of emission abatement policies are measured as the percentage changes in both real gross national product (GNP) and real gross domestic product (GDP) relative to the reference case levels. Real GNP is equal to gross domestic product (GDP) plus net foreign income transfers, and therefore provides a complete measure of the flow of income available to an economy for consumption, savings and depreciation. In the New Zealand context, changes in real GNP can be attributed to three main areas;

GNP effect = output effect (real GDP) + terms of trade effect
+ net income transfer

Output effects

A major source of the economic costs of implementing the Kyoto Protocol are the direct effects of imposing a carbon charge on greenhouse gas emitters. These include increased costs of producing emission intensive products and increased consumer prices. The increase in costs encourage Annex B producers and consumers to substitute away from low cost emission intensive technologies or products to higher cost technologies or products that produce less greenhouse gas emissions. The increase in costs to industry and consumers tends to dampen economic activity, leading to a reduction in economic activity and real GDP.

In addition, as the costs of producing emission intensive commodities increase, the incentive to relocate these industries to non-Annex B regions is increased. For example, the competitiveness of New Zealand's agricultural exports is likely to decline relative to agricultural exports from non-Annex B regions when methane emissions are subject to a carbon charge. In addition, there may be competitiveness effects within Annex B regions. These can result from different production techniques and reflect differences in the ability to abate emissions at given output levels among Annex B producers.

As a consequence of these two effects, there is a strong correlation between the size of the carbon charge and the projected reduction in real GDP from reference case levels.

Terms of trade effects

The effects of implementing the Kyoto Protocol on world prices of commodities are also important determinants of the economic cost of implementing the protocol. Terms of trade effects will arise because actions to limit emissions in Annex B countries affect the relative prices of products traded on world markets. For example, the imposition of a carbon charge (on a comprehensive basis) will lead to higher costs of production in the livestock industries and in energy intensive products, such as iron and steel production. Higher costs of production in the livestock industries result in higher world prices for wool, meat and dairy products, which would lead to an improvement in New Zealand's terms of trade over the commitment period. All things being equal, an increase in agricultural export prices would lead to an improvement in economic activity in New Zealand. (Of course, any increase in economic activity as a result of increasing world prices will be tempered by the adverse competitiveness effects discussed above.)

Income transfers

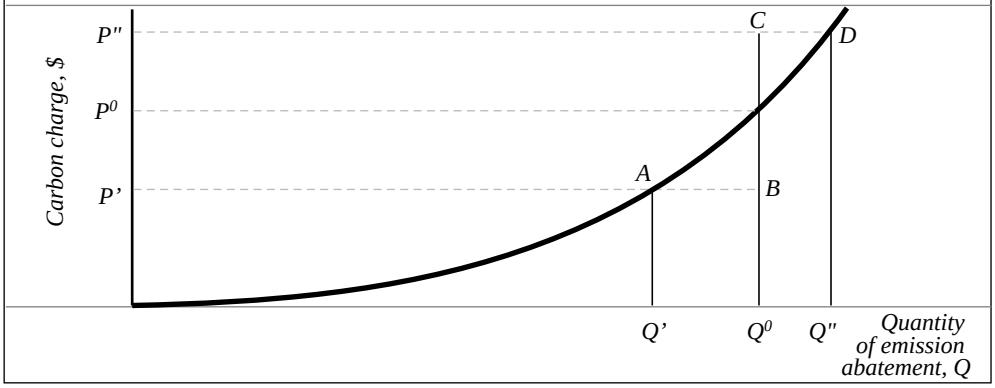
Income transfers under international emissions trading arise from the purchase and sale of emission quota and sink credits. The extent of quota purchases (sales) also affect the economic cost of emission abatement under the protocol. The value of these income transfers depends on two things: the international price of quota and the amount purchased in order to meet the emissions reduction requirements of the Kyoto Protocol.

In the case of New Zealand, which is a small country, the quota price will be given — that is, determined by prevailing supply and demand conditions in the international quota market.

The amount of quota purchased or sold by New Zealand will depend on the size of the abatement task it faces and on its access to low cost abatement opportunities. The size of the abatement task depends on reference case emissions growth, the assigned amount agreed to under the Kyoto Protocol (which in New Zealand's case is equal to its level of emissions in 1990).

A country's access to low cost abatement options can be represented by their marginal abatement cost curve (figure 4). This curve shows the cost of various levels of emission abatement at a given period in time. It relates to issues such as the ability of a country to switch from high to low emission intensive fuel sources (for example, switching gas for coal), the ability to generate emissions reductions cheaply under Articles 3.3 and 3.4 and the ability to reduce non-combustion carbon dioxide gases cost effectively. This curve, along with the prevailing market price for quota and the size of New Zealand's emission abate-

4 Marginal abatement cost curve and income transfers



ment task will govern the extent of quota sales or purchases under each scenario. For example, if New Zealand is required to reduce emissions by Q^0 and the prevailing quota price is P', then New Zealand will purchase (Q^0–Q') emission permits at P' and undertake emission abatement of the level Q' domestically. In this case, the income transfer from New Zealand will be ABQ^0Q'.

On the other hand, if the prevailing international quota price is raised to P'', New Zealand will undertake more abatement (to the level Q'') and sell Q''–Q^0 units of emission quota on the international market at the price P'', earning $CDQ''Q^0$ in net foreign income.

Scenarios considered

The New Zealand Ministry of Agriculture and Forestry commissioned ABARE to analyse a range of international climate change response policies (summarised in table 15). The scenarios varied substantially in terms of scope, specification and focus. This is for two main reasons. First, at the time of undertaking the analysis there was considerable uncertainty about the likely nature of any international climate change agreement (in terms of detail and participation). Second, even if the detail of an international agreement were known, there would remain uncertainty about the implementation of that agreement and to the range of domestic policy options available to New Zealand policy makers to achieve that agreement.

The scenarios considered, therefore, attempt to analyse the economic impacts of various policy and implementation options at the international and national levels. Broadly, there are four categories of scenarios considered.

Category 1 scenario

The first category includes a base scenario (scenario 1). This scenario forms the basis from which to compare the other scenarios. It is not a 'most likely' outcome, but it does contain some important considerations at both the international and national levels from which to gain an understanding of the economic impacts of international climate change policy. This scenario includes:

- full participation by all Annex B countries (including the US) in the abatement effort under the Kyoto Protocol;
- unrestricted use of international emissions trading;
- a policy regime that allows taxation of a comprehensive range of greenhouse gases and sources (those represented in GTEM);
- access to emission reductions under Article 3.3 of the protocol for all Annex B countries;
- the exclusion of the clean development mechanism and access to emission reductions under Article 3.4 of the protocol.

Category 2 scenarios

The second category includes a set of scenarios exploring issues relating to the design of the Kyoto Protocol. These scenarios analyse issues that are being considered in the context of the international climate change negotiations such as:

- the inclusion of the clean development mechanism (scenario 2);
- allowing access to emission reductions under Article 3.4 of the Kyoto Protocol (scenario 3);
- restrictions on international emissions trading through the commitment period reserve (scenario 4).

Category 3 scenarios

The third category includes a set of scenarios that considers issues associated with the implementation of the Kyoto protocol. These issues include:

- restricting the coverage of greenhouse gases that face the carbon charge (scenario 5);
- the role of agriculture in emission abatement, including a sensitivity analysis on the emissions response function outlined in table 6 (scenarios 6 and 7) as well as a policy of subsidising agricultural producers to undertake emission abatement rather than subject them to the carbon charge (scenario 8);
- restricting the sales of carbon credits generated under Article 3.3 for New Zealand (scenario 9);

- revenue recycling (scenario 10);
- restricting the coverage of greenhouse gases and sinks simultaneously and extending the Kyoto Protocol to 2020 (scenario 11);
- early action (scenario 11a).

Category 4 scenario

The final category includes a scenario on country participation in the Kyoto protocol. Given the considerable uncertainty about participation of various Annex B regions, this scenario excludes participation by the Russian Federation, the Ukraine and eastern Europe in the protocol (scenario 12).

15 *Description of scenarios modeled in this study*

Scenario	Description
1	Base modeling scenario: implementation of the Kyoto Protocol with full emission quota trading, Article 3.3 sinks and all Annex B countries participating but without the clean development mechanism
2	Same as (1) but with clean development mechanism included
3	Same as (1) but with estimated sink credits under Article 3.4 included
4	Same as (1) but with all countries maintaining a 90 per cent commitment period reserve
5	Same as (1) but with the carbon charge applying only to carbon dioxide emissions
6	Same as (1) but with zero abatement possibilities in New Zealand agriculture
7	Same as (1) but with high level of abatement possibilities in New Zealand agriculture
8	Same as (5) but with New Zealand agriculture having incentives to abate emissions via a domestic project based emissions trading system
9	Same as (1) but with New Zealand sink credits limited to 75 per cent of available total
10	Same as (1) but with the New Zealand government using carbon charge revenue to fund a reduction in company taxes
11	Same as (1) but with the carbon charge applying only to carbon dioxide emissions and no sinks — this scenario is run to 2020
11a	Same as (11) but with New Zealand introducing a carbon tax between 2003 and 2007
12	Same as (1) but with eastern Europe and the Russian Federation and the Ukraine not participating in emission quota trading

6. Base scenario

Under the base modeling scenario, the Kyoto Protocol is assumed to be ratified by all Annex B countries. Annex B countries are allowed to trade emission quota without limit and to count carbon sequestered from the atmosphere under Article 3.3 toward meeting their emission targets. However, benefits from the CDM and Article 3.4 sinks are not included in this scenario.

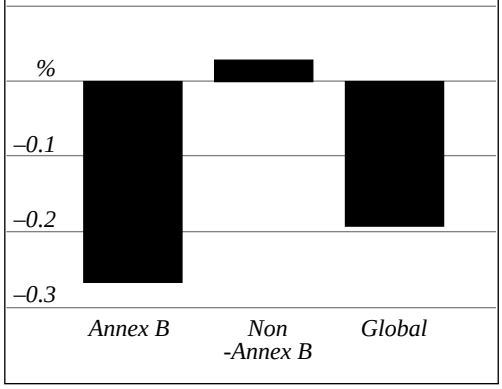
In line with current New Zealand policy, it is assumed that emission credits arising under Article 3.3 sinks are available for sale on the international emission quota market. This means that New Zealand's emission target will be achieved through domestic abatement (arising from both sink and nonsink sources) and purchases of emission quota.

Global economic impacts

The implementation of the Kyoto Protocol is projected to reduce global real GNP relative to the reference case at 2010 (figure 5). Global losses arise because emission abatement requires Annex B countries to adopt less emission intensive production technologies and move toward less emission intensive industries. These shifts move the world's resources toward previously less profitable activities and production methods, generating economic losses relative to the reference case.

In aggregate, non-Annex B countries benefit as a result of Annex B regions meeting their Kyoto targets, mainly due to the relocation of emission intensive activities to these regions. Production and exports of emission intensive goods (agricultural and energy intensive goods) in developing countries are projected to increase relative to the reference case as a result of increased export competitiveness against Annex B producers. However, this aggregate result masks significant differences in the impacts across developing countries. For example, the real

5 Changes in global real GNP at 2010 under the Kyoto Protocol with base scenario assumptions
Relative to the reference case

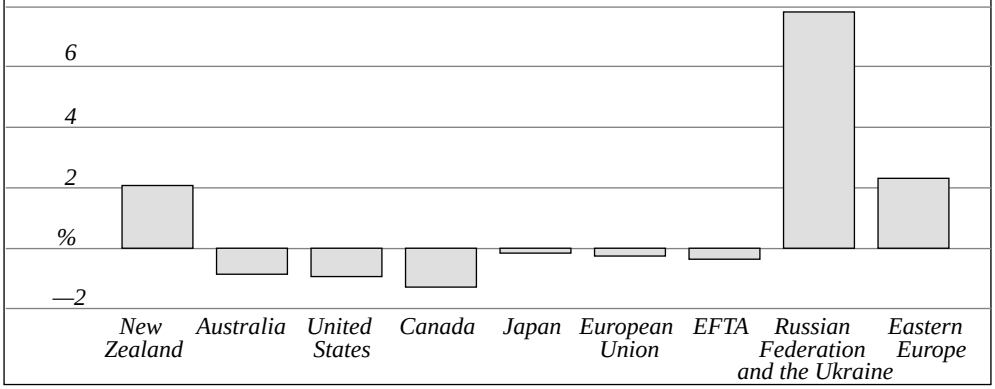


GNP in countries that rely heavily on fossil fuel exports, such as the Middle East, is projected to decline relative to the reference case. On the other hand, real GNP in agricultural exporting countries such as Argentina and Uruguay is projected to increase relative to the reference case.

Impacts on Annex B regions

The changes in real GNP for Annex B regions at 2010, relative to the reference case are presented in figure 6. Implementing the Kyoto Protocol will impose economic costs on each region, with the exception of the Russian Federation and the Ukraine, eastern Europe and New Zealand. These regions are able to exploit their low marginal abatement costs to sell quota on the international market.

6 *Changes in Annex B real GNP at 2010 under the Kyoto Protocol with base scenario assumptions* *Relative to the reference case*



For the base scenario Annex B countries trade 2.44 billion tonnes of carbon dioxide equivalent at a quota price of US$144.7 a tonne of carbon equivalent (see table 3 for the carbon charge in terms of carbon dioxide equivalent). Most of this quota trade occurs between the United States, that purchases 1.69 billion tonnes and the Russian Federation and the Ukraine, that sell around 2 billion tonnes in 2010 (table 16). Among other Annex B countries, eastern European countries sell 416 million tonnes of carbon dioxide equivalent of emission quota and the European Union is projected to buy 274 million tonnes of emission quota.

Macroeconomic impacts in New Zealand

In comparison with the reference case, the implementation of the Kyoto Protocol under base scenario assumptions reduces economic activity but

16 *Income transfers, quota purchased and domestic abatement under the base scenario at 2010*

	Income transfers	Quota purchased	Domestic abatement
	US$m 2001	Mt CO_2 equiv.	Mt CO_2 equiv.
New Zealand	984	–25	43
Australia	–2 225	56	78
United States	–66 888	1 693	1 159
Canada	–7 099	180	115
Japan	–8 387	212	80
European Union	–10 834	274	446
Russian Federation and Ukraine	78 966	–1 998	1 207
Eastern Europe	16 454	–416	300
EFTA **a**	–942	24	8
Total	96 404	2 439	3 410

a European Free Trade Area: comprises Switzerland, Norway and Iceland.

increases national income in New Zealand. At 2010, New Zealand's real GDP is 0.20 per cent lower than reference case levels as a result of the negative output effects of imposing the carbon charge (table 17). These economic costs are more than offset by the foreign income of US$983 million generated by New Zealand's sales of emission quota on the international emission quota market. Real GNP in New Zealand at 2010 rises by 2.08 per cent above its reference case level. The increase in New Zealand's real GNP would be larger were it not for the 0.27 per cent depreciation in the New Zealand dollar, that increases the cost of international debt payments and the cost to domestic investors of accessing international investment markets. The currency depreciation under this scenario is attributable to a loss in trade competitiveness and leads to a reduction in demand for New Zealand currency. This reduction more than outweighs the additional demand for New Zealand currency stemming from New Zealand's sales of emission quota.

17 *Carbon market and economic impacts in New Zealand under the base scenario at 2010*

The carbon market		
Carbon charge	US$/t C	144.7
Net quota income	US$m	982.8
Net quota sales	Mt CO_2 equiv.	24.9
Domestic abatement	Mt CO_2 equiv.	43.2
Economic impact relative to the reference case		
GDP	%	–0.20
GNP	%	2.08
Exchange rate	%	–0.27
Exports	%	–5.42
Imports	%	–0.18
Savings	%	1.80
Investment	%	0.13
Export price index	%	1.69
Import price index	%	0.13
Terms of trade	%	1.56

The terms of trade for New Zealand are projected to be 1.56 per cent

above reference case levels at 2010, mainly because of a projected increase in agricultural export prices resulting from increased costs of production in Annex B countries.

How New Zealand meets its Kyoto commitments

The forest industry in New Zealand is assumed to maximise the value of forest sinks under Article 3.3 of the protocol by selling most of the sinks on the international emission quota market. As a consequence, other sectors in the economy must undertake some domestic abatement in order for New Zealand to meet its emission target under the Kyoto Protocol.

A description of how New Zealand meets its Kyoto commitments is presented in table 18. The reference case emissions are projected to be 86.8 million tonnes of carbon dioxide equivalent at 2010. In implementing the Kyoto Protocol, New Zealand undertakes domestic emission abatement of 43.4 million tonnes of carbon dioxide equivalent (comprising 15.6 million tonnes from nonsink activities and 27.6 million tonnes from Article 3.3 sinks). This domestic abatement reduces emissions in New Zealand below their assigned amount, which enables New Zealand to sell 24.9 million tonnes of carbon dioxide equivalent on the international market. These sales leave New Zealand with an emissions inventory at 2010 equal to its assigned amount of 68.3 million tonnes of carbon dioxide equivalent.

18 How New Zealand meets its Kyoto commitments at 2010 under the base scenario

	Emissions
	Mt CO_2 equiv.
Projected reference case emissions	86.8
less domestic abatement through non-sink activities	(15.6)
less domestic abatement through Article 3.3 sinks	(27.6)
Equals emissions before net quota sales	43.4
plus net quota sales	24.9
Equals reported emissions at 2010 under the Kyoto Protocol	68.3
Assigned amount **a**	68.3

a Assumed to be the assigned amount at 2010 — that is, the assigned amount divided by 5.

Sectoral impacts in New Zealand

At the sectoral level, the implementation of the Kyoto Protocol under base scenario assumptions shifts production in New Zealand from emission intensive sectors such as agriculture, metals and electricity production into less emission intensive industries, such as services, light manufacturing, cropping and forestry (table 19). (The data presented in table 19 are a selected list of output. A detailed set of sectoral results, including emission abatement by sector, output, exports, imports and supply prices for each scenario, is presented in appendix A).

Agriculture

Within the agriculture sector there is a restructuring of production away from emission intensive agricultural commodities toward less emission intensive commodities. The imposition of a carbon charge on New Zealand agricultural producers leads to an increase in agricultural production costs, making agricultural producers and other users of agricultural products, such as food processing industries, less internationally competitive. The extent of the shift in production reflects the underlying emission intensity of the sector, and the ability of the sector to employ emission saving technologies in response to the rising carbon charge.

19 Change in sectoral outputs in New Zealand under the base scenario at 2010, relative to the reference case

	Change in output
	%
Coal	–20.6
Gas	–7.9
Petroleum and coal products	–2.4
Electricity	–7.1
Iron and steel	–22.7
Nonferrous metals	–10.7
Meat products	1.2
Dairy products	–31.8
Food products	0.8
Light manufacturing	0.6
Trade and transport	0.8
Private services	0.9
Crops	11.0
Forestry	3.3
Livestock for meat	–5.7
Other animal products	2.0
Dairy cattle	–25.5
Wool	–24.1

For example, wool and dairy production falls by much more than beef production under the base scenario. This is because wool and dairy production are more emission intensive than beef production and therefore lose international competitiveness against producers in non-Annex B regions. The reduction in wool and dairy production also leads to a reallocation of agricultural land to crops. This is due to a reduction in the price of agricultural land and a lowering of production costs for less emission intensive agricultural industries in Annex B regions relative to non-Annex B regions (which experience an increase in land prices as livestock, dairy and wool production increase).

It is important to note that the projected reallocation of land from the livestock sectors to crops is potentially overstated under the current specification of GTEM. This is because the model does not account for the competition for land between agriculture and forestry and the revenue from the sale of sink credits is not allocated to forestry but distributed to all sectors. If land were mobile between agriculture and forestry, and the sale of sink credits accounted for as additional income from forestry activities, it is likely that there would be more reallocation of land toward forestry rather than to agricultural activities such as cropping.

Processed agriculture

For processed agricultural commodities, production in New Zealand shifts away from dairy toward meat and other food products. In the case of dairy products, the cost increases imposed at the farm gate by the carbon charge are passed on to processors of dairy products. These costs reduce international competitiveness against both non-Annex B and some Annex B producers. However, the smaller increase in the cost of livestock production for meat compared with other Annex B countries results in gains in international competitiveness. However, over the longer term this effect is likely to reverse as non-Annex B producers invest in more meat production capacity.

Energy and emission intensive production

Coal production falls by over 20 per cent at 2010, relative to the reference case, while the reductions in gas and petroleum production are smaller. Petroleum and gas are less emission intensive than coal combustion and therefore consumers of gas incur relatively lower carbon charges for their energy consumption than consumers of coal.

Output from both the iron and steel and nonferrous metals sectors declines by more than 10 per cent relative to the reference case at 2010. As the iron and steel sector is an intensive consumer of coal, the introduction of the carbon charge increases iron and steel production costs, which reduces the international competitiveness of iron and steel producers in New Zealand and other Annex B countries.

The level of electricity generation falls under this scenario relative to the reference case, driven both by reduced economic activity and a shift from electricity use toward energy saving technologies in domestic production.

Less emission intensive industries

The less emission intensive industries such as light manufacturing and services are projected to increase output relative to the reference case. This reflects a reallocation of resources, labor and capital, from emission intensive industries such as agriculture, electricity and heavy manufacturing toward these less emission intensive sectors. This reallocation is brought about by a reduction in wage rates and returns to capital in New Zealand.

7. Protocol design scenarios

In this section, issues relating to the design of the Kyoto Protocol are explored. These issues are being considered in the context of the international climate change negotiations, the resolution of which could have significant implications for New Zealand's economy.

Clean development mechanism

At the resumption of COP6 in Bonn, agreement was reached on a number of issues concerning the CDM, particularly the eligibility of sinks projects (restricted to afforestation and reforestation). In this scenario the assumptions underpinning the base scenario still hold. In addition, just over 90 million tonnes of carbon dioxide equivalent are made available to Annex B regions under the CDM in each year of the commitment period. These emission reductions are available from a combination of technology transfer and forestry projects (see table 12 for details).

The introduction of the CDM as part of the Kyoto protocol results in a carbon charge of US$139 a tonne of carbon equivalent (table 20), which is lower than

20 Carbon market and economic impacts in New Zealand under the base scenario with the clean development mechanism at 2010

		Base scenario	With the clean development mechanism
The carbon market			
Carbon charge	US$/t C	144.7	138.7
Net quota income	US$m	982.8	926.3
Net quota sales	Mt CO_2 equiv.	24.9	24.5
Domestic abatement	Mt CO_2 equiv.	43.2	42.6
Economic impact relative to the reference case			
GDP	%	–0.20	–0.18
GNP	%	2.08	1.98
Exchange rate	%	–0.27	–0.26
Exports	%	–5.42	–5.16
Imports	%	–0.18	–0.18
Savings	%	1.80	1.70
Investment	%	0.13	0.13
Export price index	%	1.69	1.63
Import price index	%	0.13	0.12
Terms of trade	%	1.56	1.51

the carbon charge of US$145 for the base scenario. This is because the CDM gives Annex B regions access to additional sources of low cost emission abatement.

For this scenario, real GNP in New Zealand rises by 1.98 per cent at 2010, relative to the reference case. This represents a smaller gain in national income than projected for the base scenario. This smaller gain is attributable to the lower carbon charge prevailing in the international quota market and the reduced demand for emission quota from New Zealand. Domestic abatement in New Zealand is lower than under the base scenario level as producers are able to purchase more emission quota at a lower price. This is achieved without a significant reduction in the terms of trade.

At a sectoral level, output changes are consistent with those projected in the base scenario, although the magnitude of these changes is smaller owing to the lower carbon charge (see appendix A for details).

Article 3.4 sinks

Access to emission reduction credits under Article 3.4 of the Kyoto Protocol has been a contentious issue in the international climate change negotiations. The main areas of discussion have focused on determining which additional land use change and forestry activities would be permitted under Article 3.4 and how net emissions from these activities would be accounted for in the first commitment period. Significant progress was made on these issues at the resumption to COP6 at Bonn and at COP7 at Marrakech. At Bonn, agreement was reached on the inclusion of management of crop land, grazing land and forested land and the revegetation of degraded land as eligible activities under Article 3.4.

The assumptions underpinning the base scenario are also adopted in this scenario. In addition, Annex B regions can access emission reductions equal to 3 per cent of their assigned amount (spread evenly over the commitment period) under Article 3.4 over the commitment period. Under this arrangement and based on the assumptions provided by the New Zealand Ministry of Agriculture and Forestry, New Zealand does not obtain any net carbon sequestration from Article 3.4.

The ability to access emission abatement under Article 3.4 is projected to lead to a lower carbon charge than under the base scenario, of around US$122 a tonne of carbon equivalent (table 21). This, like scenario 2, results from the increased availability of low cost emission abatement options for Annex B countries from eligible Article 3.4 activities.

21 Carbon market and economic impacts in New Zealand under the base scenario with access to emission reductions under Article 3.4 at 2010

		Base scenario	With Article 3.4 sinks
The carbon market			
Carbon charge	US$/t C	144.7	121.8
Net quota income	US$m	982.8	742.1
Net quota sales	Mt CO_2 equiv.	24.9	22.3
Domestic abatement	Mt CO_2 equiv.	43.2	40.7
Economic impact relative to the reference case			
GDP	%	–0.20	–0.15
GNP	%	2.08	1.66
Exchange rate	%	–0.27	–0.27
Exports	%	–5.42	–4.40
Imports	%	–0.18	–0.23
Savings	%	1.80	1.38
Investment	%	0.13	0.13
Export price index	%	1.69	1.44
Import price index	%	0.13	0.11
Terms of trade	%	1.56	1.33

Under this scenario, New Zealand sells 22.3 million tonnes of carbon dioxide equivalent worth US$742 million at 2010. These quota sales are below the base scenario levels because, as discussed above, New Zealand is assumed to be the only Annex B region without Article 3.4 sinks. In other Annex B countries, the availability of emission credits under Article 3.4 reduces demand for emission quota from New Zealand relative to the base scenario.

Economic activity in New Zealand does not fall as far under this scenario as under the base scenario because of the lower carbon charge. The lower carbon charge also reduces the incentive for New Zealand producers to undertake domestic abatement. Overall, real GNP rises by less in New Zealand than under the base scenario, as the relative fall in income from sink credits outweighs a smaller fall in economic activity.

At a sectoral level, the pattern of output changes is similar to those projected in the base scenario, except that the magnitude of the changes is smaller due to the lower carbon charge (see appendix A for the complete details).

Commitment period reserve

Another contentious issue in the international climate change negotiations has been the terms for access to international emissions trading. Several proposals have been made that aim to restrict the amount of quota that can either be

bought or sold in an international market. The Bonn decision contains a reference to Article 17 (emissions trading) that agrees:

> To recommend to the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol that each Party included in Annex I shall maintain, in its national registry, a commitment period reserve which should not drop below 90 per cent of the Party's assigned amount calculated pursuant to Article 3, paragraphs 7 and 8, of the Kyoto Protocol or 100 per cent of five times its most recently reviewed inventory, whichever is lowest. (United Nations 2001)

The conditions assumed for the commitment period reserve for this scenario are less restrictive than those agreed to in the Bonn agreement (it assumes that a party's commitment period reserve should not drop below 90 per cent of its assigned amount or 90 per cent of five times its most recently reviewed inventory, whichever is lowest).

Implementing the Kyoto Protocol with a 90 per cent commitment period reserve results in a carbon charge of US$245 a tonne of carbon equivalent. This value is higher than under the base scenario because significant amounts of low cost emission quota in the Russian Federation, the Ukraine, eastern Europe and, to a lesser extent, New Zealand, are removed from the quota market. This forces quota buying countries, that have relatively high marginal costs of abatement, to undertake more domestic abatement than occurs under the base scenario.

In New Zealand, implementing the Kyoto Protocol with the commitment period reserve is projected to increase both economic activity and national income relative to the reference case (table 22). This increase in economic activity occurs because the marginal costs of abatement in New Zealand is much lower than in quota buying Annex B countries such as Japan.

Production in New Zealand of some emission intensive products such as iron and steel, meat and wool expands, relative to the reference case, at the expense of production in quota buying Annex B countries. The expansion in economic activity continues to the point where New Zealand meets its emission target of 68.3 million tonnes of carbon dioxide equivalent at 2010. This increased economic activity, when combined with the US$490 million New Zealand earns from the sale of emission quota, results in a rise in real GNP in New Zealand of 3.37 per cent, relative to the reference case, at 2010.

Under this scenario the sectoral composition of New Zealand's economy alters from the composition under the base case (table 23). New Zealand expands production in some emission intensive sectors, such as the livestock and metals

22 ***Carbon market and economic impacts in New Zealand under the base scenario with a commitment period reserve at 2010***

		Base scenario	With commitment period reserve
The carbon market			
Carbon charge	US$/t C	144.7	245.3
Net quota income	US$m	982.8	490.1
Net quota sales	Mt CO_2 equiv.	24.9	7.3
Domestic abatement	Mt CO_2 equiv.	43.2	25.7
Economic impact relative to the reference case			
GDP	%	–0.20	0.25
GNP	%	2.08	3.37
Exchange rate	%	–0.27	1.72
Exports	%	–5.42	–3.73
Imports	%	–0.18	3.37
Savings	%	1.80	5.18
Investment	%	0.13	0.83
Export price index	%	1.69	2.88
Import price index	%	0.13	0.26
Terms of trade	%	1.56	2.62

production sectors, and reduces production in less emission intensive sectors such as transport, services and manufacturing. The production of fossil fuels in New Zealand is projected to fall relative to the reference, reflecting the lower prices of these products.

In agriculture, production in the livestock sectors expands at the expense of cropping, other agricultural products and forestry. Within the livestock sector, the output of wool and meat products expands significantly while the output of dairy products, which is more emission intensive than wool or meat production, declines relative to the reference case.

23 ***Change in sectoral outputs in New Zealand under the commitment period reserve at 2010, relative to the reference case***

	%
Coal	–7.4
Gas	–0.6
Petroleum and coal products	–0.3
Electricity	1.5
Iron and steel	7.2
Nonferrous metals	2.9
Meat products	12.2
Dairy products	–5.0
Food products	–2.8
Light manufacturing	–6.0
Trade and transport	–0.7
Private services	–0.1
Crops	–5.7
Forestry	–1.2
Livestock for meat	4.2
Other animal products	–7.1
Dairy cattle	–3.5
Wool	13.2

8. Issues of implementation

This section includes a range of scenarios that consider practical and policy related issues of implementing the Kyoto Protocol. The issues considered include the coverage of greenhouse gases and sources exposed to the carbon charge, the roles of agriculture and forest sinks, revenue recycling, and early action.

Restricted gas coverage

In GTEM it is assumed that emission monitoring is perfect and costless and that carbon charges are applied at the same point that emissions are generated (point taxation). These assumptions imply that complete information on emissions is available to the regulating authority, and that there are no administrative costs associated with the policy instrument.

The assumption of point taxation is important in the context of greenhouse gas emissions from noncombustion sources. For example, it may be difficult to estimate methane and nitrous oxide emissions from the livestock sector as these emissions depend on herd size, composition (by breed and age), feed quality, environment and livestock management practices. It may not always be practical to apply a carbon charge across all greenhouse gases and sources.

Under a restricted gas coverage scenario, Annex B countries only apply the carbon charge to carbon dioxide emissions. Emissions of methane and nitrous oxide do not face the charge but are still included in each country's greenhouse gas inventory.

Macroeconomic impacts on New Zealand

With gas coverage restricted to carbon dioxide emissions the carbon charge increases from US$145 a tonne of carbon equivalent under the base scenario to US$178 a tonne (table 24). The overall cost of abatement rises because low cost abatement options for methane and nitrous oxide (particularly in agriculture) are no longer adopted. Emissions of methane and nitrous oxide increase under a restricted gas coverage scenario, with the burden of emission abatement falling increasingly on those sectors emitting carbon dioxide.

Implementing the Kyoto Protocol with restricted gas coverage is projected to affect New Zealand more significantly than other Annex B countries because

over half of New Zealand greenhouse gas emissions consist of methane emitted by livestock. These emissions are still included in New Zealand's emission target but livestock producers have no incentive to reduce their emissions as there is no carbon charge applied to them.

New Zealand cannot access low cost abatement options available from the agriculture sector, hence increasing the cost of domestic abatement. Consequently, under this scenario New Zealand abates 33.5 million tonnes of carbon dioxide equivalent at 2010, compared with 43.2 million tonnes under the base scenario. This reduction also reduces the sales of emission quota from New Zealand, relative to the base scenario.

The reduced domestic abatement in New Zealand relative to the base scenario results in real GDP in New Zealand falling by less under this scenario (table 24). This fall in real GDP is projected to be offset by almost US$740 million received from the sale of emission quota, leading to a rise in real GNP in New Zealand of 2.08 per cent relative to the reference case at 2010. This level of real GNP is identical to that established under the base scenario.

Under this scenario exports from New Zealand fall by 3.39 per cent relative to the reference case at 2010. This fall is less than under the base scenario because, under a restricted gas coverage, costs of production in the livestock industries do not rise by as much. For this reason, the terms of trade for New Zealand do not improve as much under this scenario as under the base scenario.

24 Carbon market and economic impacts in New Zealand with restricted coverage at 2010

		Base scenario	Restricted coverage
The carbon market			
Carbon charge	US$/t C	144.7	177.7
Net quota income	US$m	982.8	739.9
Net quota sales	Mt CO_2 equiv.	24.9	15.3
Domestic abatement	Mt CO_2 equiv.	43.2	33.5
Economic impact relative to the reference case			
GDP	%	–0.20	–0.06
GNP	%	2.08	2.08
Exchange rate	%	–0.27	0.73
Exports	%	–5.42	–3.39
Imports	%	–0.18	1.41
Savings	%	1.80	2.81
Investment	%	0.13	0.23
Export price index	%	1.69	0.84
Import price index	%	0.13	0.02
Terms of trade	%	1.56	0.82

Sectoral impacts on New Zealand

Under a restricted gas coverage scenario the carbon charge impacts most heavily on sectors that emit high levels of carbon dioxide per unit of output, such as metals production and electricity generation. In New Zealand, production activity shifts away from these carbon dioxide intensive areas and into industries which emit lower levels of carbon dioxide, such as agriculture and services (table 25).

25 Change in sectoral outputs in New Zealand under restricted coverage at 2010, relative to the reference case

	Base modeling scenario	Restricted coverage
	%	%
Coal	–20.6	–17.9
Gas	–7.9	–9.7
Petroleum and coal products	–2.4	–3.1
Electricity	–7.1	–8.6
Iron and steel	–22.7	–29.7
Nonferrous metals	–10.7	–17.4
Meat products	1.2	–3.6
Dairy products	–31.8	–2.5
Food products	0.8	–0.4
Light manufacturing	0.6	–3.3
Trade and transport	0.8	–0.2
Private services	0.9	0.5
Crops	11.0	0.3
Forestry	3.3	2.0
Livestock for meat	–5.7	–1.2
Other animal products	2.0	–0.3
Dairy cattle	–25.5	–2.1
Wool	–24.1	2.2

The most significant growth in production occurs in wool and forestry, while the production of iron and steel, coal and nonferrous metals experience the largest declines in production. The large reductions in wool and dairy production which occurred in the base scenario are not evident under a restricted gas coverage scenario. Instead, the production of wool, which is less carbon dioxide intensive than the production of meat and dairy products, expands while the production of meat and dairy falls.

Role of agriculture

Agriculture is an important source of greenhouse gas emissions in the New Zealand economy. The following scenarios address some issues relating to the role of agriculture in meeting New Zealand's Kyoto commitments.

Abatement options in the New Zealand livestock sector

Two scenarios were developed to test the impact of alternative abatement possibilities in the New Zealand livestock sector on the costs of implementing the protocol:

- Under a 'low abatement' scenario it is assumed that the New Zealand livestock sector cannot abate any methane without reducing output. That is,

the ability for New Zealand to access emission reducing technologies for the livestock sector is zero.

- Under the 'high abatement' scenario it is assumed that the New Zealand livestock sector is able to abate twice as much methane at each carbon charge, without reducing output, as was possible under the base modeling scenario.

As New Zealand's emissions are small compared with the rest of Annex B, these changes in livestock abatement possibilities do not significantly alter the carbon charge or pattern of emission quota trade established under the base modeling scenario (table 26). Accordingly, the impacts of these changes on sectoral output in New Zealand are minor compared with the base scenario (see appendix A).

In comparison with the reference case, the main impact of a change in New Zealand's ability to employ emissions abatement technology in the livestock sector is a change in the amount of emission quota that New Zealand can sell while still meeting its Kyoto requirements. For the 'low abatement' scenario, New Zealand is able to undertake less domestic abatement at each carbon charge, reducing the volume of quota it can sell and decreasing the level of real GNP. These effects are reversed for a 'high abatement' scenario.

26 Carbon market and economic impacts in New Zealand under two assumptions on emission saving technology in livestock at 2010

		Base scenario	Low abatement	High abatement
The carbon market				
Carbon charge	US$/t C	144.7	144.7	144.6
Net quota income	US$m	982.8	951.6	1015.6
Net quota sales	Mt CO_2 equiv.	24.9	24.1	25.8
Domestic abatement	Mt CO_2 equiv.	43.2	42.4	44.0
Economic impact relative to the reference case				
GDP	%	–0.20	–0.22	–0.18
GNP	%	2.08	1.96	2.20
Exchange rate	%	–0.27	–0.35	–0.17
Exports	%	–5.42	–5.37	–5.47
Imports	%	–0.18	–0.33	–0.02
Savings	%	1.80	1.59	2.02
Investment	%	0.13	0.11	0.15
Export price index	%	1.69	1.64	1.74
Import price index	%	0.13	0.13	0.13
Terms of trade	%	1.56	1.51	1.60

Compensation of New Zealand livestock producers for methane abatement

This scenario combines two issues: the issue of a restricted gas coverage, as was addressed in scenario 5, and a scheme where New Zealand farmers are subsidised to reduce agricultural emissions. In addition to the assumptions for scenario 5, it is assumed that New Zealand farmers receive a subsidy to undertake the same amount of emission abatement that they undertook under the base scenario. This subsidy is applied to existing methane abatement technologies capable of reducing methane emissions from livestock without reducing livestock production and covers the costs of this abatement.

The introduction of the abatement subsidy does not significantly alter the carbon charge established under a restricted gas coverage scenario, which remains at around US$178 a tonne of carbon equivalent (table 27). In comparison to the restricted gas coverage scenario (scenario 5), the only significant differences for New Zealand are:

- the subsidy received by agricultural producers enables them to increase the level of output (see appendix A);
- the subsidised emission reductions in agriculture lead to a greater level of domestic abatement;

27 Carbon market and economic impacts in New Zealand under the restricted coverage scenario where New Zealand agriculture may participate in project based abatement at 2010

		Base scenario	Restricted coverage	With subsidy
The carbon market				
Carbon charge	US$/t C	144.7	177.7	177.6
Net quota income	US$m	982.8	739.9	797.1
Net quota sales	Mt CO_2 equiv.	24.9	15.3	16.5
Domestic abatement	Mt CO_2 equiv.	43.2	33.5	34.7
Economic impact relative to the reference case				
GDP	%	–0.20	–0.06	–0.05
GNP	%	2.08	2.08	2.19
Exchange rate	%	–0.27	0.73	0.77
Exports	%	–5.42	–3.39	–3.54
Imports	%	–0.18	1.41	1.49
Savings	%	1.80	2.81	2.97
Investment	%	0.13	0.23	0.24
Export price index	%	1.69	0.84	0.88
Import price index	%	0.13	0.02	0.02
Terms of trade	%	1.56	0.82	0.86

- New Zealand can sell more emission quota while still meeting its Kyoto target; and
- there is a larger projected expansion in real GNP.

Restricted sales of sinks

Under the base scenario assumptions, New Zealand generates 27.6 million tonnes of carbon dioxide equivalent over each year of the commitment period through forestry activities under Article 3.3 of the protocol. However, there may be some uncertainty about the amount of sink credits generated because of factors such as market conditions, weather and other natural events. In this scenario, the issue of not achieving the expected level of emission reductions through Article 3.3 sinks while still meeting the same Kyoto emission target is investigated. Under this scenario, the protocol is implemented as in the base scenario but the availability of sink credits under Article 3.3 in New Zealand is reduced to 20.7 million tonnes of carbon dioxide equivalent (75 per cent of the base scenario level).

The loss of just over 7 million tonnes of sink credits from New Zealand does not significantly alter the global carbon charge or the pattern of emission quota trade between other Annex B countries established under the base scenario. The global carbon charge rises to US$145.20 a tonne of carbon from US$144.70 a tonne of carbon under the base scenario (table 28).

28 Carbon market and economic impacts in New Zealand under the base scenario when New Zealand sink credits are restricted at 2010

		Base scenario	Sink credits restricted
The carbon market			
Carbon charge	US$/t C	144.7	145.2
Net quota income	US$m	982.8	709.6
Net quota sales	Mt CO_2 equiv.	24.9	17.9
Domestic abatement	Mt CO_2 equiv.	43.2	36.2
Economic impact relative to the reference case			
GDP	%	–0.20	–0.23
GNP	%	2.08	1.53
Exchange rate	%	–0.27	–0.47
Exports	%	–5.42	–4.71
Imports	%	–0.18	–0.55
Savings	%	1.80	1.05
Investment	%	0.13	0.09
Export price index	%	1.69	1.51
Import price index	%	0.13	0.13
Terms of trade	%	1.56	1.38

In New Zealand the reduction in income from the sale of sink credits significantly reduces the economic gains New Zealand experiences from participating in the Kyoto Protocol. Real GNP in New Zealand rises by 1.53 per cent at 2010 under this scenario as opposed to rising by 2.08 per cent under the base scenario. Despite undertaking slightly less domestic abatement through nonsink activities relative to the base scenario, real GDP in New Zealand is projected to fall further under this scenario relative to the base scenario, as consumers have less income to spend on goods and services.

The sectoral results do not change significantly from the base scenario (see appendix A for sectoral results). As a lower level of resources are being shifted into low emission intensive industries than under the base scenario, output in emission intensive industries is slightly higher than in the base scenario.

Recycling of revenue from a carbon charge

The implementation of the Kyoto Protocol, including an international emissions trading scheme for greenhouse gas emissions, has the potential to generate billions of dollars worth of revenue for governments across Annex B countries. An important issue in the context of estimating the economic impacts of the Kyoto Protocol is what is done with government revenue. Under standard assumptions on emissions trading, the New Zealand government essentially sells its assigned amount on the international carbon market.

Under standard GTEM assumption, the total revenue generated by the carbon charge is returned in a lump sum fashion to households in a given region. In this scenario, it is assumed that the New Zealand government uses the revenue from the carbon charge to fund a reduction in company tax rates. This refund applies across all sectors in the New Zealand economy. The distribution of the refund is not dependent on the level of emissions produced by a given sector, rather the contribution that the sector makes to overall company tax revenue. This is one of a number of revenue recycling options that could be considered.

The introduction of revenue recycling in New Zealand does not alter the global carbon charge or the pattern of emission quota trade between other Annex B countries established in the base scenario (table 29).

In New Zealand the reduction in company tax rates reduces the costs of production across all sectors relative to the base scenario. As such, producers in New Zealand do not lose international competitiveness to the same extent as under the base scenario (see the sectoral results presented in appendix A). This reduction in production costs also reduces the output effect (measured by real GDP) relative to the base scenario. On the other hand, the increase in output

29 ***Carbon market and economic impacts in New Zealand under the base scenario with revenue recycling at 2010***

		Base scenario	With revenue recycling
The carbon market			
Carbon charge	US$/t C	144.7	144.7
Net quota income	US$m	982.8	955.2
Net quota sales	Mt CO_2 equiv.	24.9	24.2
Domestic abatement	Mt CO_2 equiv.	43.2	42.4
Economic impact relative to the reference case			
GDP	%	–0.20	–0.16
GNP	%	2.08	2.07
Exchange rate	%	–0.27	0.22
Exports	%	–5.42	–5.03
Imports	%	–0.18	0.08
Savings	%	1.80	2.28
Investment	%	0.13	0.26
Export price index	%	1.69	1.72
Import price index	%	0.13	0.13
Terms of trade	%	1.56	1.58

means that New Zealand is undertaking less emission abatement domestically. New Zealand sells less emission quota (and earns less quota income) and real GNP rises by slightly less than under the base scenario.

Other implementation issues

This section considers three further, important implementation issues:

- further restrictions in emission coverage than those already assumed;
- long term implications of international climate change policy to 2020; and
- early abatement action

Restricted gas coverage (with the exclusion of sinks)

This scenario considers the economic impacts of implementing the Kyoto Protocol with further restrictions on coverage of greenhouse gases, sources and sinks than considered above. In this scenario the carbon charge is not only restricted to carbon dioxide emissions, but also does not allow Annex B countries to access sink credits from activities under Article 3.3.

For this scenario the projected carbon charge is lower than for the restricted gas scenario (scenario 5) (table 30). This is because the inclusion of Article

3.3 results in a net source of emissions for Annex B countries in total (see table 14). By not accounting for Article 3.3 sinks, the emission abatement task for Annex B in total is reduced by 82 million tonnes of carbon dioxide equivalent, leading to a reduction in the carbon charge required to achieve the Kyoto Protocol.

Despite the lower carbon charge globally, New Zealand is considerably worse off in this scenario because it is not allowed to count its 27.6 million tonnes of carbon dioxide equivalent of sinks under Article 3.3 toward meeting its Kyoto emission target. Without these sinks New Zealand is projected to become a net buyer of emission quota, paying nearly US$626 million to purchase 13.5 million tonnes of carbon dioxide equivalent of emission quota. This significant income loss reduces real GNP in New Zealand by 0.71 per cent at 2010, compared with an increase of 2.08 per cent in GNP for the base scenario. This fall in real GNP lowers the level of economic activity by reducing demand for goods and services.

The sectoral results for this scenario reflect the same movement of production away from the carbon dioxide intensive sectors as for the restricted gas coverage scenario. However, the services sectors do not expand as much under this scenario as a result of the lower level of real GNP. In contrast, the livestock and agriculture sectors are projected to expand further than under the restricted gas coverage scenario.

30 Carbon market and economic impacts in New Zealand under the restricted coverage scenario without Article 3.3 sinks at 2010

		Base scenario	Restricted coverage	Without sinks
The carbon market				
Carbon charge	US$/t C	144.7	177.7	170.5
Net quota income	US$m	982.8	739.9	–625.8
Net quota sales	Mt CO_2 equiv.	24.9	15.3	–13.5
Domestic abatement	Mt CO_2 equiv.	43.2	33.5	4.9
Economic impact relative to the reference case				
GDP	%	–0.20	–0.06	–0.24
GNP	%	2.08	2.08	–0.71
Exchange rate	%	–0.27	0.73	–0.24
Exports	%	–5.42	–3.39	0.23
Imports	%	–0.18	1.41	–0.47
Savings	%	1.80	2.81	–0.97
Investment	%	0.13	0.23	0.03
Export price index	%	1.69	0.84	–0.02
Import price index	%	0.13	0.02	0.05
Terms of trade	%	1.56	0.82	–0.07

Restricted gas coverage (with the exclusion of sinks) – longer term impacts

The scenarios considered so far have reported the implications of various options for implementing the Kyoto Protocol at 2010, the middle of the first commitment period. Here, results for the restricted gas coverage scenario (without Article 3.3 sinks) are reported to 2020 to examine the longer term issues concerning emission abatement. It is assumed that Annex B countries maintain emissions at their Kyoto levels to 2020.

The carbon charge is projected to roughly double from 2010 to 2020 (table 31). This is because, despite holding the emission level fixed to 2020 across

31 Carbon market and economic impacts in New Zealand under the restricted coverage scenario without Article 3.3 sinks over the longer term

		2010	2020
The carbon market			
Carbon charge	US$/t C	170.5	367.0
Net quota income	US$m	–625.8	–2622.1
Quota purchased	Mt CO_2 equiv.	13.5	26.4
Domestic abatement	Mt CO_2 equiv.	4.9	13.6
Economic impact relative to the reference case			
GDP	%	–0.24	–0.84
GNP	%	–0.71	–4.31
Exchange rate	%	–0.24	–0.93
Exports	%	0.23	2.39
Imports	%	–0.47	–2.16
Savings	%	–0.97	–5.21
Investment	%	0.03	–0.44
Export price index	%	–0.02	–0.41
Import price index	%	0.05	0.30
Terms of trade	%	–0.07	–0.70

Annex B regions, the actual emission abatement task (the difference between reference case emission and target emissions) increases. As the emission abatement task is increased, low cost options to reduce emissions become more scarce. This results in the carbon charge rising further, shifting the behavior of firms and consumers to adopt alternatives to emission intensive practices and commodities.

The economic costs to New Zealand are projected to increase at a greater rate than the quota price. While the quota price doubles from 2010 to 2020 under this scenario, the reduction in real GNP relative to the reference case is more than six times that projected for the base case over the same period. This is

because of the nonlinear nature of the marginal abatement cost curves for each region (recalling figure 4) and leads to:

- a greater reduction in output from most sectors,
- higher levels of domestic abatement required; and
- an increase in the amount of quota purchased on the international market.

Over time, as the carbon charge increases, the projected impacts on sectoral output are considerably higher than under this scenario at 2010 (see appendix A).

Early emissions abatement action

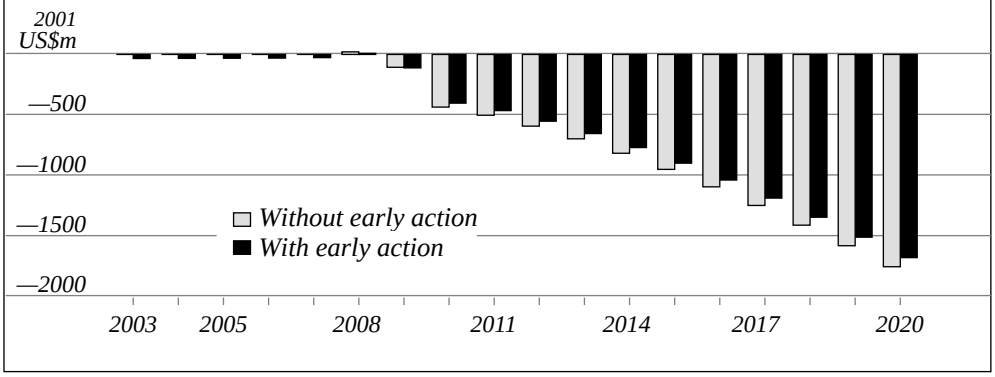
This scenario addresses the issue of implementing early emissions abatement action by New Zealand. It is generally accepted that there are likely to be both positive and negative effects of early emissions abatement action by countries. On the positive side, early emissions abatement action can result in a staged approach to reducing emissions (recalling that GTEM has no forward looking behavior by which agents in the model can foresee future emissions abatement requirements). The more quickly emissions abatement is undertaken, the higher the costs in terms of prematurely retiring capital and replacing it with new, less emissions intensive technology. On the other hand, early emissions abatement action can impose economic costs at an earlier time than is required by the Kyoto Protocol, leading to potential adverse effects on the international competitiveness of exporting industries.

Under an early emissions abatement action scenario, New Zealand unilaterally introduces a carbon charge of US$25 a tonne of carbon equivalent from 2003 to 2007. From 2008 to 2020, the carbon charge is determined by the international emissions trading scheme as part of the Kyoto Protocol. Assumptions for implementation of the Kyoto Protocol are those for the restricted gas coverage scenario with the exclusion of sinks (scenario 11).

Under an early emissions abatement scenario the carbon charge levied from 2003 to 2007 encourages the New Zealand economy to undertake emissions abatement activities over this period. At 2010, the early emissions abatement action has reduced New Zealand's reliance on the purchase of emission quota and also the costs of implementing the Kyoto Protocol (table 32).

It is important to note that 2010 is a point estimate and that the New Zealand economy does begin incurring economic costs much earlier under an early emissions abatement scenario than when no early action is taken. The net present value of the economic costs over the period 2003–10, using a 7 per cent

7 Costs of implementing the Kyoto Protocol with restricted coverage and no sinks in New Zealand *Discounted present values at 2003*



discount rate, is US$139 million higher under an early emissions abatement scenario than if no early emissions abatement action is taken (figure 7).

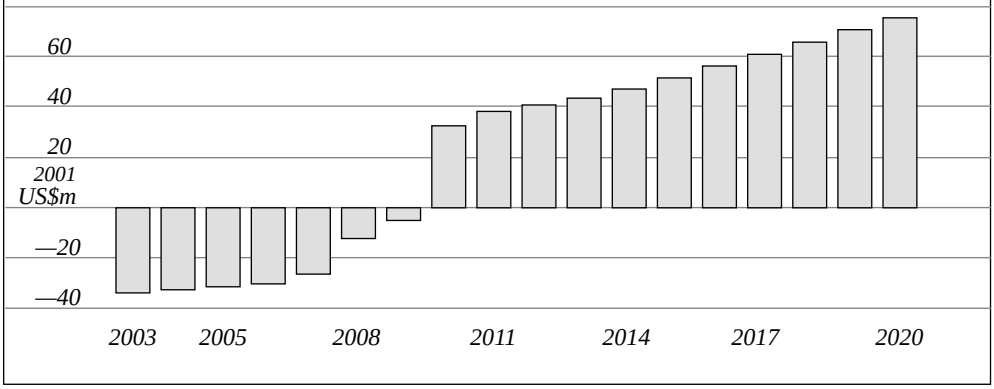
The main reason for the higher economic costs incurred under an early emissions abatement scenario is a decline in export competitiveness before 2008. This is reflected in a lower projected increase in export volumes over this period (see appendix A for detailed sectoral results). Over the longer term the benefits of an early emissions abatement scenario exceed the short term losses

32 Carbon market and economic impacts in New Zealand under the restricted coverage scenario where New Zealand undertakes early emission abatement action at 2010

		Base scenario	Restricted coverage without sinks	With early action
The carbon market				
Carbon charge	US$/t C	144.7	170.5	170.8
Net quota income	US$m	982.8	–625.8	–601.8
Quota purchased	Mt CO_2 equiv.	24.9	13.5	12.9
Domestic abatement	Mt CO_2 equiv.	43.2	4.9	5.6
Economic impact relative to the reference case				
GDP	%	–0.20	–0.24	–0.24
GNP	%	2.08	–0.71	–0.66
Exchange rate	%	–0.27	–0.24	–0.22
Exports	%	–5.42	0.23	0.18
Imports	%	–0.18	–0.47	–0.42
Savings	%	1.80	–0.97	–0.87
Investment	%	0.13	0.03	0.01
Export price index	%	1.69	–0.02	0.01
Import price index	%	0.13	0.05	0.05
Terms of trade	%	1.56	–0.07	–0.04

8 Change in real GNP when New Zealand undertakes early action before implementing the Kyoto Protocol

Discounted present values at 2003, relative to restricted coverage and no sinks



generated between 2003 to 2008. For the period 2003–20, using a 7 per cent discount rate, the economic cost to New Zealand of implementing the protocol with restricted coverage and no sinks is US$412 million lower for an early emissions abatement scenario than when no early action is taken (figure 8).

9. Country participation

Of interest to policy makers when considering the costs and benefits of ratifying the Kyoto Protocol is the participation of specific countries in the protocol. As mentioned earlier, the scenarios developed for this report assume the participation of the United States and hence do not reflect the recent decision by the United States to not ratify the protocol at this stage. A country participation scenario was developed at the request of the New Zealand Ministry of Agriculture and Forestry. This scenario assumes the participation of the United States but excludes the Russian Federation, the Ukraine and eastern Europe from the Kyoto Protocol (scenario 12).

The Russian Federation, the Ukraine and eastern Europe do not ratify the Kyoto Protocol

This scenario analyses the effect of removing the two major quota sellers, eastern Europe and the Russian Federation and the Ukraine from the interna-

33 Carbon market and economic impacts in New Zealand under the base scenario where the Russian Federation, the Ukraine and eastern Europe do not ratify the Kyoto Protocol at 2010

		Base scenario	Without Russian, Ukrainian and eastern European ratification
The carbon market			
Carbon charge	US$/t C	144.7	576.9
Net quota income	US$m	982.8	7678.3
Net quota sales	Mt CO_2 equiv.	24.9	48.8
Domestic abatement	Mt CO_2 equiv.	43.2	67.1
Economic impact relative to the reference case			
GDP	%	–0.20	–1.20
GNP	%	2.08	13.23
Exchange rate	%	–0.27	2.49
Exports	%	–5.42	–26.91
Imports	%	–0.18	3.78
Savings	%	1.80	15.83
Investment	%	0.13	–0.36
Export price index	%	1.69	7.54
Import price index	%	0.13	1.31
Terms of trade	%	1.56	6.15

tional emissions trading market, while including the remaining Annex B regions. Removing the Russian Federation, the Ukraine and eastern Europe from the emission quota market significantly reduces access to low cost emission quota, which leads to a large rise in the carbon charge relative to the base scenario (table 33).

New Zealand is projected to benefit under this scenario compared with the base scenario through the sale of significant amounts of quota on the international market, more than offsetting the decline in real GDP caused by the high carbon charge.

Appendix A: Modeling results, by scenario

Scenario	Description
1	Base modeling scenario. Implementation of the Kyoto Protocol with full emission quota trading, Article 3.3 sinks and all Annex B countries participating but without the clean development mechanism
2	Same as (1) but with clean development mechanism included
3	Same as (1) but with estimated sink credits under Article 3.4 included
4	Same as (1) but with all countries maintaining a 90 per cent commitment period reserve
5	Same as (1) but with the carbon charge applying only to carbon dioxide emissions
6	Same as (1) but with zero abatement possibilities in New Zealand agriculture
7	Same as (1) but with high level of abatement possibilities in New Zealand agriculture
8	Same as (5) but with New Zealand agriculture having incentives to abate emissions via a domestic project based emissions trading system
9	Same as (1) but with of New Zealand sink credits limited to 75 per cent of available total
10	Same as (1) but with the New Zealand government using carbon charge revenue to fund a reduction in company taxes
11	Same as (1) but with the carbon charge applying only to carbon dioxide emissions and no sinks — this scenario is run to 2020
11a	Same as (11) but with New Zealand introducing a carbon charge between 2003 and 2007
12	Same as (1) but with eastern Europe and the Russian Federation and the Ukraine not participating in emission quota trading

A.1 *Change in emissions in New Zealand under the base modeling (scenario 1) at 2010, relative to reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–7.8	–48.0	..	–30.8	..	–19.9
Oil	..	..	..	–0.2	–5.0	..	–0.6
Gas	..	..	..	–7.9	–12.3	..	–10.6
Petroleum and coal products	..	–4.9	–2.5	..	..	..	–4.4
Electricity	–40.1	–18.0	–83.3	..	..	..	–25.3
Iron and steel	–27.8	..	–27.8	..	..	..	–27.8
Nonferrous metals	–29.9	..	–4.7	–22.1	..	..	–25.3
Chemicals, rubber and plastic	..	–2.1	1.3	..	..	..	0.7
Clothing	..	..	..	..	..	..	..
Meat products	–22.0	..	..	..	..	..	–21.9
Dairy products	–47.7	..	–29.9	..	..	..	–45.4
Food	–23.3	..	4.3	..	..	..	–22.5
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–18.5	..	10.1	–4.7	..	..	–10.4
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.8	8.0	..	..	..	–4.6
Trade and transport	..	1.0	–0.2	..	..	0.8	–0.2
Private services	..	..	–1.7	..	..	..	–1.6
Public services	–2.5	–6.9	0.9	..	..	..	–3.2
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.6	..	..	–29.6	–26.0
Other cereal grains	..	..	–8.7	..	..	–28.9	–25.3
Crops	..	..	2.6	..	..	–20.2	–16.4
Forestry	..	..	–2.5	..	..	..	–2.3
Fisheries	..	..	–4.2	..	..	..	–4.1
Livestock for meat	..	..	–12.1	..	–8.9	–5.7	–8.3
Other animal products	..	..	–4.5	..	–1.5	2.0	–1.4
Dairy cattle	..	..	–31.4	..	–29.9	–25.5	–28.4
Wool	..	..	–29.5		–26.7	–24.1	–26.1

.. No significant emissions from this sector.

A.2 *Carbon market and economic impacts in New Zealand under the base modeling at 2010*

The carbon market		
Carbon charge	US$/t C	144.7
Net quota income	US$m	982.8
Net quota sales	Mt CO_2 equiv.	24.9
Domestic abatement	Mt CO_2 equiv.	43.2
Economic impact relative to the reference case		
GDP	%	–0.20
GNP	%	2.08
Exchange rate	%	–0.27
Exports	%	–5.42
Imports	%	–0.18
Savings	%	1.80
Investment	%	0.13
Export price index	%	1.69
Import price index	%	0.13
Terms of trade	%	1.56

A.3 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under the base modeling at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.6	–26.3	–15.0	..	–7.1
Oil	–0.2	–0.4	0.3	–3.6	–3.3
Gas	–7.9	–10.1	..	..	–6.2
Petroleum and coal products	–2.4	–2.0	1.6	–1.9	–2.1
Electricity	–7.1	–3.8	..	..	21.1
Iron and steel	–22.7	–22.2	–39.7	11.9	16.6
Nonferrous metals	–10.7	–10.4	–17.0	–9.6	7.1
Chemicals, rubber and plastic	1.0	1.3	4.7	–1.3	–0.2
Clothing	–7.6	–7.5	–15.7	3.9	3.2
Meat products	1.2	1.4	1.8	–2.8	4.5
Dairy products	–31.8	–31.6	–36.2	7.6	9.0
Food	0.8	1.1	2.7	–1.3	–0.1
Pulp, paper and publishing	1.8	2.0	4.6	–1.3	–0.9
Other wood products	0.1	0.4	–0.7	1.2	0.2
Minerals	–0.2	–0.1	7.3	–5.7	0.1
Nonmetallic minerals	0.4	0.7	3.5	–2.0	0.6
Light manufacturing	0.6	0.7	1.4	0.0	0.1
Other manufacturing	4.7	4.9	5.7	0.8	–0.4
Construction	0.0	0.3	0.4	–0.5	0.0
Trade and transport	0.8	1.1	2.1	0.7	–0.6
Private services	0.9	1.2	4.4	–1.5	–1.5
Public services	2.9	3.0	4.1	–4.1	–1.3
Other services	3.0	3.5	..	..	–1.5
Rice	..	..	..	..	..
Wheat	–2.2	–4.2	..	–7.1	–2.4
Other cereal grains	–1.2	–3.2	14.2	–6.2	–2.3
Crops	11.0	9.1	17.9	–8.6	–3.5
Forestry	3.3	4.0	5.4	..	0.8
Fisheries	0.6	1.3	0.6	–0.5	0.8
Livestock for meat	–5.7	–8.3	4.7	–13.8	7.3
Other animal products	2.0	–0.4	2.1	–8.7	1.2
Dairy cattle	–25.5	–27.5	..	..	18.9
Wool	–24.1	–27.0	–43.2	–16.8	19.9

.. Not a significant activity.

A.4 Change in emissions in New Zealand under the clean development mechanism (scenario 2) at 2010, relative to the reference case

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–6.9	–47.6	..	–30.6	..	–19.6
Oil	..	..	..	–0.2	–4.8	..	–0.6
Gas	..	..	..	–7.6	–11.9	..	–10.2
Petroleum and coal products	..	–4.4	–2.4	..	..	..	–4.0
Electricity	–39.1	–17.4	–82.7	..	..	..	–24.6
Iron and steel	–26.9	..	–26.9	..	..	..	–26.9
Nonferrous metals	–29.3	..	–4.5	–21.8	..	..	–24.9
Chemicals, rubber and plastic	..	–2.0	1.3	..	..	..	0.7
Clothing	..	..	..	..	..	..	..
Meat products	–21.5	..	..	..	..	..	–21.4
Dairy products	–46.5	..	–28.8	..	..	..	–44.3
Food	–22.9	..	4.2	..	..	..	–22.1
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–18.2	..	9.8	–4.7	..	..	–10.2
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.6	7.8	..	..	..	–4.4
Trade and transport	..	1.0	–0.2	..	..	0.8	–0.2
Private services	..	..	–1.7	..	..	..	–1.5
Public services	–2.4	–6.7	0.8	..	..	..	–3.1
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.3	..	..	–29.5	–25.9
Other cereal grains	..	..	–8.5	..	..	–28.8	–25.2
Crops	..	..	2.4	..	..	–20.5	–16.7
Forestry	..	..	–2.4	..	..	..	–2.3
Fisheries	..	..	–4.1	..	..	..	–4.0
Livestock for meat	..	..	–11.7	..	–8.4	–5.4	–7.8
Other animal products	..	..	–4.3	..	–1.1	2.0	–1.1
Dairy cattle	..	..	–30.4	..	–28.7	–24.6	–27.3
Wool	..	..	–28.3	..	–25.4	–23.0	–24.8

.. Not a significant activity.

A.5 *Carbon market and economic impacts in New Zealand under the clean development mechanism at 2010*

The carbon market		
Carbon charge	US$/t C	138.7
Net quota income	US$m	926.3
Net quota sales	Mt CO_2 equiv.	24.5
Domestic abatement	Mt CO_2 equiv.	42.6
Economic impact relative to the reference case		
GDP	%	–0.18
GNP	%	1.98
Exchange rate	%	–0.26
Exports	%	–5.16
Imports	%	–0.18
Savings	%	1.70
Investment	%	0.13
Export price index	%	1.63
Import price index	%	0.12
Terms of trade	%	1.51

A.6 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under the clean development mechanism at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.5	–26.2	–15.5	..	–7.4
Oil	–0.2	–0.4	0.3	–3.4	–3.2
Gas	–7.6	–9.7	..	..	–6.0
Petroleum and coal products	–2.3	–2.0	1.4	–1.8	–2.0
Electricity	–6.9	–3.7	..	..	20.3
Iron and steel	–21.9	–21.5	–38.5	11.5	15.9
Nonferrous metals	–10.4	–10.0	–16.5	–9.2	6.8
Chemicals, rubber and plastic	1.0	1.2	4.5	–1.2	–0.2
Clothing	–7.3	–7.2	–15.0	3.7	3.1
Meat products	1.3	1.5	2.1	–2.8	4.3
Dairy products	–30.7	–30.5	–35.0	7.2	8.6
Food	0.8	1.0	2.6	–1.3	–0.1
Pulp, paper and publishing	1.7	1.9	4.4	–1.3	–0.8
Other wood products	0.1	0.4	–0.7	1.1	0.2
Minerals	–0.2	–0.1	7.0	–5.5	0.1
Nonmetallic minerals	0.4	0.7	3.3	–1.9	0.6
Light manufacturing	0.6	0.7	1.4	0.0	0.0
Other manufacturing	4.5	4.7	5.5	0.8	–0.3
Construction	0.0	0.3	0.4	–0.5	0.0
Trade and transport	0.8	1.1	2.1	0.6	–0.6
Private services	0.9	1.1	4.3	–1.4	–1.5
Public services	2.8	2.8	4.0	–3.9	–1.2
Other services	2.9	3.3	..	..	–1.5
Rice	..	..	..	..	..
Wheat	–2.0	–4.0	..	–6.8	–2.3
Other cereal grains	–1.1	–3.1	13.7	–5.9	–2.2
Crops	10.5	8.7	17.2	–8.3	–3.4
Forestry	3.2	3.9	5.3	..	0.8
Fisheries	0.6	1.3	0.6	–0.4	0.8
Livestock for meat	–5.4	–7.9	4.8	–13.5	7.0
Other animal products	2.0	–0.2	2.2	–8.3	1.2
Dairy cattle	–24.6	–26.6	..	..	18.2
Wool	–23.0	–25.8	–41.2	–16.6	19.1

.. Not a significant activity.

A.7 *Change in emissions in New Zealand under the protocol with Article 3.4 sinks (scenario 3) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	2.2	–44.3	..	–26.9	..	–15.6
Oil	..	..	..	–0.1	–3.7	..	–0.4
Gas	..	..	..	–6.7	–10.1	..	–8.8
Petroleum and coal products	..	–2.7	–2.2	..	..	..	–2.6
Electricity	–35.9	–15.5	–80.7	..	..	..	–22.3
Iron and steel	–24.3	..	–24.3	..	..	..	–24.3
Nonferrous metals	–27.3	..	–3.7	–20.7	..	..	–23.4
Chemicals, rubber and plastic	..	–1.7	1.2	..	..	..	0.7
Clothing	..	..	..	..	..	..	..
Meat products	–20.2	..	..	..	..	..	–20.1
Dairy products	–43.2	..	–25.7	..	..	..	–40.9
Food	–21.6	..	3.8	..	..	..	–20.9
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–17.2	..	8.9	–2.6	..	..	–8.6
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.2	7.0	..	..	..	–4.1
Trade and transport	..	0.9	–0.2	..	..	0.7	–0.1
Private services	..	..	–1.5	..	..	..	–1.3
Public services	–2.2	–6.3	0.6	..	..	..	–2.9
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–8.4	..	..	–22.0	–19.5
Other cereal grains	..	..	–7.6	..	..	–21.4	–18.9
Crops	..	..	1.9	..	..	–13.4	–10.9
Forestry	..	..	–2.3	..	..	..	–2.1
Fisheries	..	..	–3.7	..	..	..	–3.7
Livestock for meat	..	..	–10.4	..	–6.9	–4.6	–6.5
Other animal products	..	..	–3.8	..	–0.4	2.0	–0.5
Dairy cattle	..	..	–27.5	..	–25.2	–22.0	–24.2
Wool	..	..	–24.9	..	–21.7	–19.8	–21.2

.. No significant emissions from this sector.

A.8 *Carbon market and economic impacts in New Zealand under the protocol with Article 3.4 sinks at 2010*

The carbon market		
Carbon charge	US$/t C	121.8
Net quota income	US$m	742.1
Net quota sales	Mt CO_2 equiv.	22.3
Domestic abatement	Mt CO_2 equiv.	40.7
Economic impact relative to the reference case		
GDP	%	–0.15
GNP	%	1.66
Exchange rate	%	–0.27
Exports	%	–4.40
Imports	%	–0.23
Savings	%	1.38
Investment	%	0.13
Export price index	%	1.44
Import price index	%	0.11
Terms of trade	%	1.33

A.9 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under the protocol with Article 3.4 sinks at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–17.9	–23.4	–12.3	..	–7.3
Oil	–0.1	–0.2	0.4	–3.1	–2.9
Gas	–6.7	–8.7	..	..	–5.6
Petroleum and coal products	–2.1	–1.8	1.3	–1.6	–1.8
Electricity	–6.2	–3.4	..	..	18.0
Iron and steel	–19.7	–19.3	–34.9	10.3	14.1
Nonferrous metals	–9.1	–8.8	–14.5	–8.3	6.0
Chemicals, rubber and plastic	0.9	1.1	4.1	–1.1	–0.2
Clothing	–6.4	–6.3	–13.1	3.2	2.7
Meat products	1.5	1.7	2.6	–2.6	3.8
Dairy products	–27.5	–27.4	–31.3	6.2	7.6
Food	0.8	1.0	2.5	–1.3	–0.1
Pulp, paper and publishing	1.6	1.7	4.1	–1.2	–0.7
Other wood products	0.2	0.4	–0.4	0.9	0.2
Minerals	–0.2	0.0	6.3	–4.9	0.1
Nonmetallic minerals	0.4	0.6	3.1	–1.7	0.5
Light manufacturing	0.6	0.8	1.5	0.0	0.0
Other manufacturing	4.1	4.3	5.1	0.6	–0.3
Construction	0.0	0.2	0.5	–0.5	0.0
Trade and transport	0.7	1.0	2.0	0.4	–0.5
Private services	0.8	1.0	4.0	–1.3	–1.3
Public services	2.4	2.4	3.7	–3.6	–1.1
Other services	2.4	2.8	..	..	–1.3
Rice	..	..	..	..	..
Wheat	–1.7	–3.4	..	–6.1	–2.0
Other cereal grains	–0.9	–2.6	12.0	–5.1	–1.9
Crops	9.2	7.7	15.0	–7.3	–2.9
Forestry	2.9	3.5	4.8	..	0.8
Fisheries	0.5	1.2	0.4	–0.2	0.7
Livestock for meat	–4.6	–6.8	4.9	–12.4	6.1
Other animal products	2.0	0.0	2.1	–7.3	1.0
Dairy cattle	–22.0	–23.9	..	..	16.0
Wool	–19.8	–22.3	–35.5	–15.9	16.9

.. Not a significant activity.

A.10 *Change in emissions in New Zealand under the commitment period reserve (scenario 4) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–9.0	–7.3	..	–15.0	..	–10.7
Oil	..	..	..	–4.4	–6.2	..	–4.5
Gas	..	..	..	–0.6	–2.5	..	–1.7
Petroleum and coal products	..	–4.2	–0.6	..	..	..	–3.5
Electricity	3.6	3.1	–13.1	..	..	..	3.0
Iron and steel	7.0	..	7.0	..	..	..	7.0
Nonferrous metals	0.8	..	4.0	–4.8	..	..	–2.4
Chemicals, rubber and plastic	..	–1.1	–0.4	..	..	..	–0.5
Clothing	..	..	..	..	..	..	..
Meat products	9.6	..	..	..	..	..	9.5
Dairy products	–6.9	..	–4.3	..	..	..	–6.6
Food	–5.0	..	–1.9	..	..	..	–4.9
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–1.7	..	1.3	–2.9	..	..	–2.4
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	0.4	1.9	..	..	..	0.4
Trade and transport	..	–1.1	–0.7	..	..	–0.7	–0.7
Private services	..	..	0.4	..	..	..	0.3
Public services	3.4	1.4	2.7	..	..	..	2.5
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	0.4	..	..	–16.0	–13.2
Other cereal grains	..	..	–0.5	..	..	–16.8	–14.0
Crops	..	..	–5.9	..	..	–21.2	–18.6
Forestry	..	..	–1.5	..	..	..	–1.4
Fisheries	..	..	–1.2	..	..	..	–1.2
Livestock for meat	..	..	4.1	..	3.0	4.2	3.3
Other animal products	..	..	–7.2	..	–8.1	–7.1	–7.9
Dairy cattle	..	..	–3.7	..	–5.5	–3.5	–4.8
Wool	..	..	13.2	..	11.9	13.2	12.3

.. No significant emissions from this sector.

A.11 *Carbon market and economic impacts in New Zealand under the commitment period reserve at 2010*

The carbon market		
Carbon charge	US$/t C	245.3
Net quota income	US$m	490.1
Net quota sales	Mt CO_2 equiv.	7.3
Domestic abatement	Mt CO_2 equiv.	25.7
Economic impact relative to the reference case		
GDP	%	0.25
GNP	%	3.37
Exchange rate	%	1.72
Exports	%	–3.73
Imports	%	3.37
Savings	%	5.18
Investment	%	0.83
Export price index	%	2.88
Import price index	%	0.26
Terms of trade	%	2.62

A.12 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under the commitment period reserve at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–7.4	–10.8	–22.1	..	–8.1
Oil	–4.4	–6.3	–10.9	0.4	–4.1
Gas	–0.6	–0.7	..	..	–0.1
Petroleum and coal products	–0.3	–0.5	–6.0	2.5	–2.4
Electricity	1.5	1.1	..	..	2.8
Iron and steel	7.2	7.2	15.6	–9.2	2.6
Nonferrous metals	2.9	2.9	–0.4	–13.7	2.9
Chemicals, rubber and plastic	–0.6	–0.6	–1.6	0.7	0.0
Clothing	–7.3	–7.4	–16.9	5.6	1.5
Meat products	12.2	12.4	24.4	–7.9	2.0
Dairy products	–5.0	–4.9	–5.7	–1.1	1.6
Food	–2.8	–2.9	–7.3	4.9	0.3
Pulp, paper and publishing	–1.7	–1.8	–5.0	2.2	0.3
Other wood products	–3.0	–3.1	–11.4	7.0	0.3
Minerals	0.4	0.4	–0.9	–0.2	0.5
Nonmetallic minerals	0.1	0.1	–2.9	0.9	0.4
Light manufacturing	–6.0	–6.1	–13.6	3.7	0.5
Other manufacturing	–5.2	–5.3	–7.8	3.1	0.5
Construction	0.8	0.8	–7.1	4.0	0.3
Trade and transport	–0.7	–0.8	–8.6	5.9	0.3
Private services	–0.1	–0.2	–10.4	6.3	0.3
Public services	2.2	2.2	–10.1	8.3	0.4
Other services	3.6	3.5	..	..	0.4
Rice	..	..	..	..	..
Wheat	0.5	1.1	..	10.5	2.1
Other cereal grains	–0.4	0.1	–12.7	9.2	2.0
Crops	–5.7	–5.7	–8.5	4.9	1.2
Forestry	–1.2	–1.4	–0.4	..	–0.2
Fisheries	–0.9	–1.7	4.7	–5.8	–2.1
Livestock for meat	4.2	5.3	34.2	–24.5	3.7
Other animal products	–7.1	–7.1	–7.2	3.9	1.5
Dairy cattle	–3.5	–3.2	..	..	2.7
Wool	13.2	15.1	23.8	–38.1	6.4

.. Not a significant activity.

A.13 *Change in emissions in New Zealand under restricted coverage (scenario 5) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–5.6	–46.9	..	–18.8	..	–12.4
Oil	..	..	..	–0.9	–1.8	..	–1.0
Gas	..	..	..	–9.7	–10.5	..	–10.1
Petroleum and coal products	..	–7.9	–3.4	..	..	..	–7.1
Electricity	–44.9	–21.9	–86.0	..	..	..	–29.4
Iron and steel	–35.0	..	–35.0	..	..	..	–35.0
Nonferrous metals	–36.3	..	–10.9	–27.9	..	..	–31.4
Chemicals, rubber and plastic	..	–3.3	0.6	..	..	..	–0.1
Clothing	..	..	..	..	..	..	..
Meat products	–27.1	..	..	..	..	..	–27.0
Dairy products	–26.9	..	0.8	..	..	..	–23.4
Food	–25.9	..	3.6	..	..	..	–25.2
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–20.4	..	10.7	–5.5	..	..	–11.6
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–5.1	9.7	..	..	..	–4.9
Trade and transport	..	0.2	–1.3	..	..	–0.2	–1.3
Private services	..	..	–2.6	..	..	..	–2.4
Public services	–3.2	–8.6	–0.1	..	..	..	–4.3
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.1	..	..	–28.8	–25.2
Other cereal grains	..	..	–9.1	..	..	–28.8	–25.3
Crops	..	..	–7.9	..	..	–27.8	–24.4
Forestry	..	..	–4.5	..	..	..	–4.2
Fisheries	..	..	–5.3	..	..	..	–5.2
Livestock for meat	..	..	–8.2	..	–1.2	–1.2	–1.5
Other animal products	..	..	–7.0	..	–0.4	–0.3	–1.0
Dairy cattle	..	..	–10.3	..	–2.2	–2.1	–2.3
Wool	..	..	–5.2	..	2.1	2.2	2.0

.. No significant emissions from this sector.

A.14 *Carbon market and economic impacts in New Zealand under restricted coverage at 2010*

The carbon market		
Carbon charge	US$/t C	177.7
Net quota income	US$m	739.9
Net quota sales	Mt CO_2 equiv.	15.3
Domestic abatement	Mt CO_2 equiv.	33.5
Economic impact relative to the reference case		
GDP	%	–0.06
GNP	%	2.08
Exchange rate	%	0.73
Exports	%	–3.39
Imports	%	1.41
Savings	%	2.81
Investment	%	0.23
Export price index	%	0.84
Import price index	%	0.02
Terms of trade	%	0.82

A.15 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under restricted coverage at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–17.9	–23.4	–3.5	..	–16.1
Oil	–0.9	–1.7	–0.6	–4.4	–5.3
Gas	–9.7	–12.2	..	..	–9.2
Petroleum and coal products	–3.1	–3.3	–2.1	–1.6	–3.1
Electricity	–8.6	–4.6	..	..	24.6
Iron and steel	–29.7	–29.1	–47.9	11.1	19.6
Nonferrous metals	–17.4	–17.3	–24.7	–12.9	8.5
Chemicals, rubber and plastic	0.1	0.1	0.3	0.3	–0.1
Clothing	–0.1	–0.1	–2.0	1.5	–0.6
Meat products	–3.6	–3.6	–8.3	3.4	0.1
Dairy products	–2.5	–2.5	–2.8	1.9	–0.3
Food	–0.4	–0.5	–1.5	2.0	–0.5
Pulp, paper and publishing	0.2	0.2	0.0	0.4	–0.5
Other wood products	–2.1	–2.1	–7.6	4.3	0.5
Minerals	–2.2	–2.4	4.3	–6.4	–0.1
Nonmetallic minerals	–0.4	–0.3	–3.8	1.3	1.1
Light manufacturing	–3.3	–3.4	–7.2	1.7	0.4
Other manufacturing	–0.3	–0.3	–1.0	1.6	–0.2
Construction	0.3	0.3	–4.8	2.2	0.5
Trade and transport	–0.2	–0.2	–3.4	2.8	–0.2
Private services	0.5	0.4	–1.3	1.1	–1.1
Public services	2.3	2.3	–2.3	3.2	–0.7
Other services	2.9	2.7	..	..	–1.2
Rice	..	..	..	..	..
Wheat	–1.0	–1.1	..	–0.9	–0.7
Other cereal grains	–1.0	–1.1	–0.1	–0.5	–0.7
Crops	0.3	0.3	0.5	–0.5	–0.8
Forestry	2.0	2.4	4.4	..	0.3
Fisheries	0.1	0.3	1.8	–2.0	–0.4
Livestock for meat	–1.2	–1.2	–0.8	0.2	–0.5
Other animal products	–0.3	–0.3	–0.3	–1.2	–0.4
Dairy cattle	–2.1	–2.1	..	..	–0.2
Wool	2.2	2.4	6.0	–0.9	–0.1

.. Not a significant activity.

A.16 *Change in domestic emissions under low abatement in New Zealand agriculture (scenario 6) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–7.7	–47.9	..	–30.7	..	–19.8
Oil	..	..	..	–0.1	–4.9	..	–0.5
Gas	..	..	..	–7.8	–12.3	..	–10.5
Petroleum and coal products	..	–4.8	–2.5	..	..	..	–4.4
Electricity	–40.1	–18.0	–83.3	..	..	..	–25.3
Iron and steel	–27.6	..	–27.6	..	..	..	–27.6
Nonferrous metals	–29.6	..	–4.4	–21.8	..	..	–25.1
Chemicals, rubber and plastic	..	–2.0	1.4	..	..	..	0.8
Clothing	..	..	..	..	..	..	..
Meat products	–22.1	..	..	..	..	..	–22.0
Dairy products	–48.5	..	–30.9	..	..	..	–46.3
Food	–23.2	..	4.4	..	..	..	–22.5
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–18.4	..	10.2	–4.7	..	..	–10.3
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.8	8.0	..	..	..	–4.6
Trade and transport	..	1.0	–0.2	..	..	0.9	–0.1
Private services	..	..	–1.7	..	..	..	–1.6
Public services	–2.6	–6.9	0.8	..	..	..	–3.2
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.7	..	..	–29.7	–26.0
Other cereal grains	..	..	–8.8	..	..	–28.9	–25.3
Crops	..	..	3.0	..	..	–19.8	–16.1
Forestry	..	..	–2.4	..	..	..	–2.2
Fisheries	..	..	–4.1	..	..	..	–4.1
Livestock for meat	..	..	–12.4	..	–6.0	–6.0	–6.2
Other animal products	..	..	–4.5	..	2.1	2.1	1.4
Dairy cattle	..	..	–32.2	..	–26.4	–26.4	–26.5
Wool	..	..	–30.3	..	–25.0	–25.0	–25.0

.. No significant emissions from this sector.

A.17 *Carbon market and economic impacts in New Zealand under low abatement in New Zealand agriculture at 2010*

The carbon market		
Carbon charge	US$/t C	144.7
Net quota income	US$m	951.6
Net quota sales	Mt CO_2 equiv.	24.1
Domestic abatement	Mt CO_2 equiv.	42.4
Economic impact relative to the reference case		
GDP	%	–0.22
GNP	%	1.96
Exchange rate	%	–0.35
Exports	%	–5.37
Imports	%	–0.33
Savings	%	1.59
Investment	%	0.11
Export price index	%	1.64
Import price index	%	0.13
Terms of trade	%	1.51

A.18 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under low abatement in New Zealand agriculture at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.5	–26.2	–14.8	..	–7.1
Oil	–0.1	–0.3	0.4	–3.6	–3.2
Gas	–7.8	–10.0	..	..	–6.2
Petroleum and coal products	–2.4	–2.0	1.8	–1.9	–2.0
Electricity	–7.1	–3.8	..	..	21.2
Iron and steel	–22.4	–21.9	–39.5	12.1	16.6
Nonferrous metals	–10.4	–10.0	–16.6	–9.4	7.1
Chemicals, rubber and plastic	1.1	1.4	5.0	–1.4	–0.2
Clothing	–7.7	–7.6	–15.7	3.9	3.3
Meat products	1.1	1.3	1.6	–2.8	4.6
Dairy products	–32.8	–32.6	–37.4	7.9	9.4
Food	1.0	1.2	3.1	–1.6	–0.1
Pulp, paper and publishing	1.9	2.1	5.0	–1.5	–0.9
Other wood products	0.3	0.5	–0.2	0.9	0.2
Minerals	–0.1	0.1	7.6	–5.7	0.1
Nonmetallic minerals	0.5	0.8	4.0	–2.2	0.6
Light manufacturing	0.8	1.0	2.0	–0.1	0.0
Other manufacturing	5.0	5.3	6.3	0.7	–0.4
Construction	0.0	0.3	0.8	–0.8	0.0
Trade and transport	0.9	1.2	2.6	0.4	–0.6
Private services	0.9	1.2	4.9	–1.7	–1.5
Public services	2.8	2.9	4.6	–4.5	–1.3
Other services	2.9	3.4	..	..	–1.6
Rice	..	..	..	..	..
Wheat	–2.2	–4.4	..	–7.4	–2.5
Other cereal grains	–1.2	–3.3	14.9	–6.5	–2.4
Crops	11.4	9.5	18.6	–8.9	–3.6
Forestry	3.5	4.2	5.6	..	0.9
Fisheries	0.7	1.4	0.5	–0.3	0.9
Livestock for meat	–6.0	–8.6	4.2	–13.7	7.5
Other animal products	2.1	–0.4	2.2	–9.0	1.3
Dairy cattle	–26.4	–28.4	..	..	19.8
Wool	–25.0	–27.9	–44.7	–16.3	20.5

.. Not a significant activity.

A.19 *Change in domestic emissions under high abatement in New Zealand agriculture (scenario 7) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–7.9	–48.1	..	–30.9	..	–20.0
Oil	..	..	..	–0.3	–5.1	..	–0.7
Gas	..	..	..	–7.9	–12.4	..	–10.6
Petroleum and coal products	..	–4.8	–2.5	..	..	..	–4.4
Electricity	–40.2	–18.1	–83.3	..	..	..	–25.4
Iron and steel	–28.1	..	–28.1	..	..	..	–28.1
Nonferrous metals	–30.2	..	–5.1	–22.4	..	..	–25.6
Chemicals, rubber and plastic	..	–2.2	1.2	..	..	..	0.6
Clothing	..	..	..	..	..	..	..
Meat products	–21.9	..	..	..	..	..	–21.8
Dairy products	–46.8	..	–28.8	..	..	..	–44.5
Food	–23.4	..	4.2	..	..	..	–22.6
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–18.5	..	10.1	–4.8	..	..	–10.4
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.7	8.1	..	..	..	–4.5
Trade and transport	..	0.9	–0.2	..	..	0.8	–0.2
Private services	..	..	–1.7	..	..	..	–1.6
Public services	–2.5	–6.8	0.9	..	..	..	–3.1
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.6	..	..	–29.6	–25.9
Other cereal grains	..	..	–8.7	..	..	–28.9	–25.3
Crops	..	..	2.2	..	..	–20.5	–16.8
Forestry	..	..	–2.6	..	..	..	–2.5
Fisheries	..	..	–4.2	..	..	..	–4.2
Livestock for meat	..	..	–11.9	..	–11.9	–5.5	–10.4
Other animal products	..	..	–4.6	..	–5.1	1.9	–4.2
Dairy cattle	..	..	–30.6	..	–33.6	–24.6	–30.4
Wool	..	..	–28.7	..	–28.5	–23.2	–27.2

.. No significant emissions from this sector.

A.20 *Carbon market and economic impacts in New Zealand under high abatement in New Zealand agriculture at 2010*

The carbon market		
Carbon charge	US$/t C	144.6
Net quota income	US$m	1015.6
Net quota sales	Mt CO_2 equiv.	25.8
Domestic abatement	Mt CO_2 equiv.	44.0
Economic impact relative to the reference case		
GDP	%	–0.18
GNP	%	2.20
Exchange rate	%	–0.17
Exports	%	–5.47
Imports	%	–0.02
Savings	%	2.02
Investment	%	0.15
Export price index	%	1.74
Import price index	%	0.13
Terms of trade	%	1.60

A.21 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under high abatement in New Zealand agriculture at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.7	–26.5	–15.2	..	–7.1
Oil	–0.3	–0.5	0.2	–3.6	–3.3
Gas	–7.9	–10.1	..	..	–6.2
Petroleum and coal products	–2.4	–2.1	1.4	–1.8	–2.1
Electricity	–7.1	–3.8	..	..	21.1
Iron and steel	–23.0	–22.5	–40.0	11.7	16.6
Nonferrous metals	–11.1	–10.7	–17.4	–9.7	7.1
Chemicals, rubber and plastic	0.9	1.1	4.3	–1.2	–0.2
Clothing	–7.5	–7.4	–15.6	4.0	3.1
Meat products	1.3	1.5	2.0	–2.8	4.4
Dairy products	–30.7	–30.5	–35.0	7.2	8.6
Food	0.7	0.9	2.3	–1.1	–0.1
Pulp, paper and publishing	1.7	1.9	4.2	–1.1	–0.8
Other wood products	0.0	0.2	–1.3	1.4	0.2
Minerals	–0.4	–0.3	7.0	–5.7	0.1
Nonmetallic minerals	0.3	0.7	2.9	–1.7	0.6
Light manufacturing	0.3	0.4	0.7	0.2	0.1
Other manufacturing	4.2	4.5	5.1	1.0	–0.3
Construction	0.1	0.3	–0.1	–0.3	0.0
Trade and transport	0.8	1.1	1.7	0.9	–0.6
Private services	0.9	1.2	3.9	–1.2	–1.5
Public services	2.9	3.0	3.5	–3.6	–1.2
Other services	3.1	3.6	..	..	–1.5
Rice	..	..	..	..	..
Wheat	–2.1	–4.1	..	–6.7	–2.3
Other cereal grains	–1.2	–3.2	13.4	–5.8	–2.3
Crops	10.5	8.6	17.1	–8.2	–3.4
Forestry	3.2	3.8	5.3	..	0.8
Fisheries	0.6	1.2	0.8	–0.7	0.6
Livestock for meat	–5.5	–8.0	5.1	–13.9	7.1
Other animal products	1.9	–0.5	2.0	–8.4	1.1
Dairy cattle	–24.6	–26.6	..	..	18.1
Wool	–23.2	–26.0	–41.6	–17.3	19.4

.. Not a significant activity.

A.22 *Change in domestic emissions under restricted coverage scenario where New Zealand agriculture may participate in project based abatement (scenario 8) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–5.6	–47.0	..	–18.9	..	–12.5
Oil	..	..	..	–0.9	–1.8	..	–1.0
Gas	..	..	..	–9.7	–10.5	..	–10.2
Petroleum and coal products	..	–7.9	–3.4	..	..	..	–7.1
Electricity	–44.9	–21.9	–86.0	..	..	..	–29.4
Iron and steel	–35.1	..	–35.1	..	..	..	–35.1
Nonferrous metals	–36.4	..	–11.1	–28.0	..	..	–31.5
Chemicals, rubber and plastic	..	–3.4	0.5	..	..	..	–0.1
Clothing	..	..	..	..	..	..	..
Meat products	–27.2	..	..	..	..	..	–27.1
Dairy products	–27.0	..	0.6	..	..	..	–23.5
Food	–26.0	..	3.5	..	..	..	–25.2
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–20.4	..	10.7	–5.5	..	..	–11.6
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–5.1	9.7	..	..	..	–4.8
Trade and transport	..	0.2	–1.3	..	..	–0.2	–1.3
Private services	..	..	–2.6	..	..	..	–2.3
Public services	–3.1	–8.6	0.0	..	..	..	–4.2
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.2	..	..	–28.8	–25.3
Other cereal grains	..	..	–9.2	..	..	–28.8	–25.3
Crops	..	..	–7.9	..	..	–27.8	–24.4
Forestry	..	..	–4.6	..	..	..	–4.3
Fisheries	..	..	–5.3	..	..	..	–5.2
Livestock for meat	..	..	–8.3	..	–4.5	–1.2	–3.9
Other animal products	..	..	–7.0	..	–6.2	–0.3	–5.6
Dairy cattle	..	..	–10.4	..	–5.5	–2.2	–4.5
Wool	..	..	–5.2	..	–1.3	2.2	–0.5

.. No significant emissions from this sector.

A.23 *Carbon market and economic impacts in New Zealand under the restricted coverage scenario where New Zealand agriculture may participate in project based abatement at 2010*

The carbon market		
Carbon charge	US$/t C	177.6
Net quota income	US$m	797.1
Net quota sales	Mt CO_2 equiv.	16.5
Domestic abatement	Mt CO_2 equiv.	34.7
Economic impact relative to the reference case		
GDP	%	–0.05
GNP	%	2.19
Exchange rate	%	0.77
Exports	%	–3.54
Imports	%	1.49
Savings	%	2.97
Investment	%	0.24
Export price index	%	0.88
Import price index	%	0.02
Terms of trade	%	0.86

A.24 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under the restricted coverage scenario where New Zealand agriculture may participate in project based abatement at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–18.0	–23.4	–3.6	..	–16.1
Oil	–0.9	–1.7	–0.7	–4.4	–5.3
Gas	–9.7	–12.3	..	..	–9.2
Petroleum and coal products	–3.2	–3.4	–2.2	–1.5	–3.1
Electricity	–8.6	–4.6	..	..	24.6
Iron and steel	–29.8	–29.2	–47.9	11.0	19.5
Nonferrous metals	–17.5	–17.4	–24.8	–12.9	8.5
Chemicals, rubber and plastic	0.0	0.1	0.2	0.3	–0.1
Clothing	–0.1	–0.1	–2.2	1.6	–0.6
Meat products	–3.7	–3.6	–8.5	3.5	0.1
Dairy products	–2.6	–2.6	–3.0	2.0	–0.3
Food	–0.5	–0.5	–1.7	2.1	–0.5
Pulp, paper and publishing	0.2	0.2	–0.2	0.5	–0.5
Other wood products	–2.2	–2.1	–7.8	4.4	0.5
Minerals	–2.3	–2.5	4.1	–6.4	–0.1
Nonmetallic minerals	–0.4	–0.3	–4.0	1.4	1.1
Light manufacturing	–3.4	–3.5	–7.5	1.8	0.4
Other manufacturing	–0.4	–0.5	–1.3	1.7	–0.2
Construction	0.3	0.3	–5.0	2.3	0.5
Trade and transport	–0.2	–0.2	–3.6	2.9	–0.2
Private services	0.5	0.4	–1.5	1.2	–1.1
Public services	2.3	2.4	–2.5	3.3	–0.7
Other services	3.0	2.9	..	..	–1.2
Rice	..	..	..	..	..
Wheat	–1.1	–1.2	..	–1.0	–0.8
Other cereal grains	–1.1	–1.2	–0.1	–0.5	–0.8
Crops	0.3	0.3	0.5	–0.5	–0.8
Forestry	2.0	2.3	4.3	..	0.2
Fisheries	0.1	0.2	1.9	–2.1	–0.4
Livestock for meat	–1.2	–1.3	–0.8	0.2	–0.5
Other animal products	–0.3	–0.3	–0.3	–1.3	–0.4
Dairy cattle	–2.2	–2.3	..	..	–0.2
Wool	2.2	2.3	6.0	–0.9	–0.2

.. Not a significant activity.

A.25 *Change in domestic emissions when New Zealand sink credits are restricted (scenario 9) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–7.7	–47.9	..	–30.6	..	–19.8
Oil	..	..	..	0.0	–4.9	..	–0.4
Gas	..	..	..	–7.8	–12.2	..	–10.5
Petroleum and coal products	..	–4.8	–2.4	..	..	..	–4.4
Electricity	–40.1	–17.9	–83.4	..	..	..	–25.2
Iron and steel	–27.4	..	–27.4	..	..	..	–27.4
Nonferrous metals	–29.4	..	–4.0	–21.5	..	..	–24.8
Chemicals, rubber and plastic	..	–1.8	1.6	..	..	..	1.0
Clothing	..	..	..	..	..	..	..
Meat products	–21.7	..	..	..	..	..	–21.6
Dairy products	–47.3	..	–29.4	..	..	..	–45.1
Food	–23.1	..	4.6	..	..	..	–22.4
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–18.4	..	10.3	–4.6	..	..	–10.3
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.8	8.0	..	..	..	–4.6
Trade and transport	..	1.0	–0.2	..	..	0.8	–0.2
Private services	..	..	–1.8	..	..	..	–1.6
Public services	–2.9	–7.3	0.5	..	..	..	–3.6
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–9.4	..	..	–29.4	–25.8
Other cereal grains	..	..	–8.5	..	..	–28.7	–25.1
Crops	..	..	2.7	..	..	–20.1	–16.3
Forestry	..	..	–2.2	..	..	..	–2.1
Fisheries	..	..	–4.1	..	..	..	–4.0
Livestock for meat	..	..	–11.9	..	–8.7	–5.5	–8.0
Other animal products	..	..	–4.4	..	–1.3	2.1	–1.2
Dairy cattle	..	..	–31.0	..	–29.5	–25.1	–28.0
Wool	..	..	–29.4	..	–26.6	–24.0	–26.0

.. No significant emissions from this sector.

A.26 *Carbon market and economic impacts in New Zealand when New Zealand sink credits are restricted at 2010*

The carbon market		
Carbon charge	US$/t C	145.2
Net quota income	US$m	709.6
Net quota sales	Mt CO_2 equiv.	17.9
Domestic abatement	Mt CO_2 equiv.	36.2
Economic impact relative to the reference case		
GDP	%	–0.23
GNP	%	1.53
Exchange rate	%	–0.47
Exports	%	–4.71
Imports	%	–0.55
Savings	%	1.05
Investment	%	0.09
Export price index	%	1.51
Import price index	%	0.13
Terms of trade	%	1.38

A.27 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand when New Zealand sink credits are restricted at 2010, relative to the reference case*

	Output	Employment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.4	–26.1	–14.7	..	–7.0
Oil	0.0	–0.2	0.5	–3.5	–3.1
Gas	–7.8	–9.9	..	..	–6.1
Petroleum and coal products	–2.3	–2.0	2.0	–2.1	–2.0
Electricity	–7.0	–3.8	..	..	21.3
Iron and steel	–22.2	–21.7	–39.4	12.4	16.7
Nonferrous metals	–10.0	–9.7	–16.3	–9.3	7.2
Chemicals, rubber and plastic	1.3	1.6	5.4	–1.5	–0.2
Clothing	–7.5	–7.3	–15.0	3.4	3.3
Meat products	1.6	1.8	2.9	–3.2	4.6
Dairy products	–31.3	–31.1	–35.6	7.3	9.1
Food	1.1	1.3	3.5	–1.8	–0.1
Pulp, paper and publishing	2.1	2.3	5.5	–1.6	–0.9
Other wood products	0.4	0.6	0.4	0.6	0.2
Minerals	0.1	0.3	7.9	–5.6	0.2
Nonmetallic minerals	0.5	0.8	4.7	–2.5	0.6
Light manufacturing	1.1	1.3	2.8	–0.3	0.0
Other manufacturing	5.4	5.7	7.0	0.3	–0.4
Construction	0.0	0.2	1.3	–1.1	0.0
Trade and transport	0.8	1.2	3.1	0.0	–0.7
Private services	0.9	1.1	5.5	–2.0	–1.6
Public services	2.5	2.6	5.1	–4.6	–1.3
Other services	2.4	2.8	..	..	–1.6
Rice	..	..	..	..	..
Wheat	–1.9	–3.9	..	–7.0	–2.3
Other cereal grains	–1.0	–2.9	14.4	–6.0	–2.2
Crops	11.1	9.2	18.0	–8.5	–3.3
Forestry	3.7	4.4	5.8	..	1.0
Fisheries	0.7	1.6	0.3	–0.1	1.0
Livestock for meat	–5.5	–7.9	4.8	–13.7	7.5
Other animal products	2.1	–0.2	2.3	–8.4	1.4
Dairy cattle	–25.1	–27.1	..	..	19.2
Wool	–24.0	–26.8	–43.3	–16.7	20.2

.. Not a significant activity.

A.28 *Change in emissions in New Zealand under revenue recycling (scenario 10) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–16.8	–48.9	..	–30.4	..	–21.5
Oil	..	..	..	–0.5	–5.3	..	–0.9
Gas	..	..	..	–7.4	–11.8	..	–10.1
Petroleum and coal products	..	–8.6	–1.9	..	..	..	–7.4
Electricity	–38.7	–16.5	–82.5	..	..	..	–23.8
Iron and steel	–26.1	..	–26.1	..	..	..	–26.1
Nonferrous metals	–28.2	..	–2.3	–20.4	..	..	–23.6
Chemicals, rubber and plastic	..	–1.7	2.0	..	..	..	1.4
Clothing	..	..	..	..	..	..	..
Meat products	–19.8	..	..	..	..	..	–19.7
Dairy products	–45.1	..	–26.4	..	..	..	–42.7
Food	–22.4	..	5.6	..	..	..	–21.6
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–18.1	..	10.7	–4.5	..	..	–10.1
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–4.6	8.5	..	..	..	–4.4
Trade and transport	..	0.6	–0.3	..	..	0.6	–0.3
Private services	..	..	–1.6	..	..	..	–1.4
Public services	–2.8	–7.3	0.7	..	..	..	–3.5
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–8.4	..	..	–28.8	–25.2
Other cereal grains	..	..	–7.7	..	..	–28.3	–24.6
Crops	..	..	1.5	..	..	–21.2	–17.4
Forestry	..	..	–2.9	..	..	..	–2.7
Fisheries	..	..	–4.0	..	..	..	–3.9
Livestock for meat	..	..	–10.7	..	–7.6	–4.4	–7.0
Other animal products	..	..	–4.9	..	–2.0	1.4	–1.9
Dairy cattle	..	..	–28.7	..	–27.4	–22.8	–25.8
Wool	..	..	–28.8	..	–26.1	–23.6	–25.5

.. No significant emissions from this sector.

A.29 *Carbon market and economic impacts in New Zealand under revenue recycling at 2010*

The carbon market		
Carbon charge	US$/t C	144.7
Net quota income	US$m	955.2
Net quota sales	Mt CO_2 equiv.	24.2
Domestic abatement	Mt CO_2 equiv.	42.4
Economic impact relative to the reference case		
GDP	%	–0.16
GNP	%	2.07
Exchange rate	%	0.22
Exports	%	–5.03
Imports	%	0.08
Savings	%	2.28
Investment	%	0.26
Export price index	%	1.72
Import price index	%	0.13
Terms of trade	%	1.58

A.30 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under revenue recycling at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.2	–25.9	–15.5	..	–6.1
Oil	–0.5	–1.0	–0.8	–2.9	–2.1
Gas	–7.4	–9.5	..	..	–3.8
Petroleum and coal products	–2.0	–1.8	3.7	–2.8	–1.7
Electricity	–6.5	–3.5	..	..	23.0
Iron and steel	–21.0	–20.5	–37.7	11.9	17.0
Nonferrous metals	–8.8	–8.4	–14.5	–9.3	7.5
Chemicals, rubber and plastic	1.5	1.8	5.2	–1.0	0.6
Clothing	–5.6	–5.5	–12.3	3.4	3.6
Meat products	3.8	4.0	7.1	–3.6	4.8
Dairy products	–28.6	–28.4	–32.5	6.5	9.2
Food	1.8	2.0	4.4	–1.7	0.5
Pulp, paper and publishing	1.7	1.9	3.9	–0.9	0.3
Other wood products	0.3	0.6	–0.5	1.2	1.1
Minerals	–0.1	0.0	5.5	–4.4	1.5
Nonmetallic minerals	0.7	1.0	3.9	–2.0	1.5
Light manufacturing	1.0	1.2	2.0	0.0	0.9
Other manufacturing	4.7	4.9	5.5	1.1	0.6
Construction	0.1	0.4	2.3	–1.5	0.5
Trade and transport	0.6	0.9	0.3	1.5	0.9
Private services	0.8	1.0	1.6	–0.1	0.2
Public services	2.4	2.4	0.6	–2.2	0.6
Other services	2.6	3.0	..	..	0.7
Rice	..	..	..	..	..
Wheat	–1.1	–3.1	..	–5.6	–1.2
Other cereal grains	–0.3	–2.2	12.8	–4.7	–1.1
Crops	9.5	7.6	15.3	–6.9	–2.0
Forestry	2.8	3.3	4.4	..	2.1
Fisheries	0.7	1.4	–2.1	1.9	2.3
Livestock for meat	–4.4	–6.9	3.4	–12.5	8.6
Other animal products	1.4	–1.0	1.5	–6.6	2.3
Dairy cattle	–22.8	–24.8	..	..	19.9
Wool	–23.6	–26.4	–43.8	–15.7	21.3

.. Not a significant activity.

A.31 *Change in emissions in New Zealand under restricted coverage and no sinks (scenario 11) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–2.9	–45.5	..	–17.2	..	–10.9
Oil	..	..	..	–0.1	–0.9	..	–0.1
Gas	..	..	..	–8.7	–9.5	..	–9.2
Petroleum and coal products	..	–7.0	–2.9	..	..	..	–6.2
Electricity	–43.4	–20.3	–85.5	..	..	..	–27.9
Iron and steel	–31.7	..	–31.7	..	..	..	–31.7
Nonferrous metals	–33.1	..	–6.9	–24.5	..	..	–28.1
Chemicals, rubber and plastic	..	–1.7	2.1	..	..	..	1.4
Clothing	..	..	..	..	..	..	..
Meat products	–25.6	..	..	..	..	..	–25.5
Dairy products	–23.6	..	4.7	..	..	..	–20.0
Food	–24.7	..	4.8	..	..	..	–23.9
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–19.6	..	11.1	–4.9	..	..	–10.9
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–5.3	9.0	..	..	..	–5.1
Trade and transport	..	0.4	–1.1	..	..	0.0	–1.1
Private services	..	..	–2.7	..	..	..	–2.5
Public services	–5.0	–10.2	–2.1	..	..	..	–6.0
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–7.9	..	..	–27.9	–24.3
Other cereal grains	..	..	–7.9	..	..	–28.0	–24.4
Crops	..	..	–7.7	..	..	–27.8	–24.3
Forestry	..	..	–3.0	..	..	..	–2.8
Fisheries	..	..	–4.6	..	..	..	–4.5
Livestock for meat	..	..	–6.9	..	0.0	0.1	–0.3
Other animal products	..	..	–6.6	..	–0.1	0.0	–0.7
Dairy cattle	..	..	–7.1	..	1.1	1.2	0.9
Wool	..	..	–4.5	..	2.6	2.7	2.5

.. No significant emissions from this sector.

A.32 *Carbon market and economic impacts in New Zealand under restricted coverage and no sinks at 2010*

The carbon market		
Carbon charge	US$/t C	170.5
Net quota income	US$m	–625.8
Quota purchased	Mt CO_2 equiv.	13.5
Domestic abatement	Mt CO_2 equiv.	4.9
Economic impact relative to the reference case		
GDP	%	–0.24
GNP	%	–0.71
Exchange rate	%	–0.24
Exports	%	0.23
Imports	%	–0.47
Savings	%	–0.97
Investment	%	0.03
Export price index	%	–0.02
Import price index	%	0.05
Terms of trade	%	–0.07

A.33 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under restricted coverage and no sinks at 2010, relative to the reference case*

	Output	Employment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–16.2	–21.5	–1.4	..	–15.4
Oil	–0.1	–0.4	0.5	–4.1	–4.4
Gas	–8.7	–11.2	..	..	–8.9
Petroleum and coal products	–2.7	–3.0	0.0	–2.4	–2.7
Electricity	–7.9	–4.2	..	..	24.2
Iron and steel	–26.2	–25.7	–44.7	12.5	19.1
Nonferrous metals	–13.5	–13.4	–20.6	–11.2	8.4
Chemicals, rubber and plastic	1.7	1.6	3.8	–0.6	–0.1
Clothing	0.9	0.8	2.3	–1.1	–0.2
Meat products	–1.9	–1.8	–3.5	1.1	0.4
Dairy products	1.5	1.4	1.7	0.8	0.0
Food	0.8	0.8	2.4	–0.5	–0.4
Pulp, paper and publishing	1.5	1.4	4.0	–1.2	–0.7
Other wood products	–0.8	–0.8	–2.1	1.0	0.4
Minerals	–0.5	–0.4	6.9	–5.9	0.3
Nonmetallic minerals	0.3	0.3	1.7	–1.4	0.9
Light manufacturing	–0.5	–0.5	–0.5	0.0	0.3
Other manufacturing	3.4	3.3	4.8	–1.1	–0.2
Construction	0.0	0.0	–0.5	–0.4	0.3
Trade and transport	0.0	–0.1	1.4	–0.8	–0.5
Private services	0.3	0.2	3.9	–1.5	–1.4
Public services	0.2	0.3	2.7	0.2	–1.0
Other services	–0.1	–0.4	..	..	–1.6
Rice	..	..	..	..	..
Wheat	0.1	0.5	..	0.0	0.2
Other cereal grains	0.1	0.5	0.3	0.4	0.1
Crops	0.3	0.8	0.5	0.1	0.2
Forestry	3.5	4.1	6.2	..	0.8
Fisheries	0.7	1.4	0.3	0.0	0.9
Livestock for meat	0.1	0.5	–1.1	1.4	0.5
Other animal products	0.0	0.5	0.0	0.4	0.5
Dairy cattle	1.2	1.6	..	..	0.6
Wool	2.7	3.4	5.6	0.3	0.9

.. Not a significant activity.

A.34 *Carbon market and economic impacts in New Zealand under restricted coverage and no sinks at 2015*

The carbon market		
Carbon charge	US$/t C	254.1
Net quota income	US$m	–1345.2
Quota purchased	Mt CO_2 equiv.	19.5
Domestic abatement	Mt CO_2 equiv.	8.8
Economic impact relative to the reference case		
GDP	%	–0.46
GNP	%	–1.90
Exchange rate	%	–0.52
Exports	%	1.06
Imports	%	–1.09
Savings	%	–2.42
Investment	%	–0.12
Export price index	%	–0.14
Import price index	%	0.13
Terms of trade	%	–0.28

A.35 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under restricted coverage and no sinks at 2015, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.1	–25.7	4.2	..	–17.0
Oil	0.0	–0.4	0.5	–5.8	–5.5
Gas	–12.3	–15.4	..	..	–11.3
Petroleum and coal products	–3.6	–3.9	1.8	–4.0	–3.4
Electricity	–12.0	–5.1	..	..	36.2
Iron and steel	–35.8	–35.0	–58.6	20.0	28.4
Nonferrous metals	–18.7	–18.6	–28.8	–14.5	11.9
Chemicals, rubber and plastic	2.7	2.7	6.0	–1.2	–0.1
Clothing	1.1	1.1	3.9	–2.1	–0.2
Meat products	–2.2	–2.1	–3.6	0.5	0.6
Dairy products	2.7	2.7	3.1	0.6	0.2
Food	1.6	1.5	4.3	–1.4	–0.5
Pulp, paper and publishing	2.7	2.6	7.0	–2.1	–1.2
Other wood products	–0.8	–0.7	–1.3	0.4	0.4
Minerals	–0.5	–0.4	10.6	–8.7	0.4
Nonmetallic minerals	0.4	0.5	3.3	–2.5	1.3
Light manufacturing	0.1	0.0	1.2	–0.5	0.3
Other manufacturing	6.2	6.0	8.5	–2.2	–0.5
Construction	–0.2	–0.2	0.6	–1.2	0.4
Trade and transport	0.0	–0.1	3.2	–2.1	–0.7
Private services	0.4	0.3	7.6	–3.0	–2.2
Public services	–0.1	–0.1	5.9	–0.9	–1.7
Other services	–1.2	–1.5	..	..	–2.5
Rice	..	..	..	..	..
Wheat	0.5	1.3	..	0.1	0.5
Other cereal grains	0.4	1.2	0.3	0.8	0.5
Crops	0.3	1.2	0.5	0.4	0.6
Forestry	4.9	5.8	8.3	..	1.2
Fisheries	1.1	2.3	–0.9	1.1	1.8
Livestock for meat	0.3	1.2	–1.6	1.5	1.0
Other animal products	0.0	0.8	0.0	0.7	1.0
Dairy cattle	2.3	3.1	..	..	1.1
Wool	2.9	4.0	6.1	0.5	1.4

.. Not a significant activity.

A.36 *Carbon market and economic impacts in New Zealand under restricted coverage and no sinks at 2020*

The carbon market		
Carbon charge	US$/t C	367.0
Net quota income	US$m	–2622.1
Quota purchased	Mt CO_2 equiv.	26.4
Domestic abatement	Mt CO_2 equiv.	13.6
Economic impact relative to the reference case		
GDP	%	–0.84
GNP	%	–4.31
Exchange rate	%	–0.93
Exports	%	2.39
Imports	%	–2.16
Savings	%	–5.21
Investment	%	–0.44
Export price index	%	–0.41
Import price index	%	0.30
Terms of trade	%	–0.70

A.37 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand under restricted coverage and no sinks at 2020, relative to the reference case*

	Output	Employment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–23.3	–29.0	10.4	..	–18.1
Oil	–0.1	–0.5	0.4	–7.6	–6.4
Gas	–16.8	–20.5	..	..	–13.5
Petroleum and coal products	–4.6	–4.9	4.6	–6.1	–4.1
Electricity	–17.3	–5.3	..	..	51.0
Iron and steel	–46.1	–44.9	–70.9	29.6	40.5
Nonferrous metals	–25.7	–25.5	–39.6	–17.9	16.9
Chemicals, rubber and plastic	4.2	4.2	9.2	–2.0	–0.1
Clothing	1.1	1.0	5.9	–3.9	–0.1
Meat products	–2.7	–2.5	–3.4	–0.7	1.0
Dairy products	4.2	4.2	4.7	0.3	0.4
Food	2.7	2.7	6.8	–2.9	–0.6
Pulp, paper and publishing	4.6	4.6	11.5	–3.4	–1.9
Other wood products	–0.5	–0.3	0.8	–1.1	0.4
Minerals	–0.6	–0.4	16.0	–12.7	0.5
Nonmetallic minerals	0.5	0.7	5.4	–4.2	1.7
Light manufacturing	1.3	1.2	4.4	–1.6	0.2
Other manufacturing	10.3	10.2	13.9	–4.2	–0.8
Construction	–0.6	–0.4	2.2	–2.6	0.5
Trade and transport	0.0	0.0	5.7	–4.3	–1.0
Private services	0.6	0.4	13.2	–5.2	–3.3
Public services	–0.9	–0.8	11.3	–2.9	–2.7
Other services	–3.7	–3.9	..	..	–3.6
Rice	..	..	..	..	..
Wheat	1.0	2.2	..	0.5	1.0
Other cereal grains	0.8	2.1	0.2	1.5	1.0
Crops	0.3	1.7	0.4	0.8	1.2
Forestry	6.5	7.9	10.4	..	1.7
Fisheries	1.6	3.5	–4.2	3.7	3.2
Livestock for meat	0.5	1.9	–2.6	1.9	1.7
Other animal products	–0.2	1.2	–0.2	1.0	1.6
Dairy cattle	3.6	4.9	..	..	1.9
Wool	3.2	4.8	6.8	0.7	2.1

.. Not a significant activity.

A.38 *Change in domestic emissions after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks (scenario 11a) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–85.7	–58.6	..	–24.3	..	–31.9
Oil	..	..	..	–0.1	–7.2	..	–0.6
Gas	..	..	..	–8.9	–15.3	..	–12.8
Petroleum and coal products	..	–55.5	–2.9	..	..	..	–46.2
Electricity	–43.7	–20.7	–85.6	..	..	..	–28.2
Iron and steel	–31.4	..	–31.4	..	..	..	–31.4
Nonferrous metals	–32.6	..	–6.2	–32.8	..	..	–32.6
Chemicals, rubber and plastic	..	–1.7	2.0	..	..	..	1.3
Clothing	..	..	..	..	..	..	..
Meat products	–25.7	..	..	..	..	..	–25.6
Dairy products	–23.8	..	4.5	..	..	..	–20.2
Food	–24.8	..	4.7	..	..	..	–24.0
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–19.7	..	11.1	–4.9	..	..	–10.9
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–5.3	9.0	..	..	..	–5.1
Trade and transport	..	0.4	–1.2	..	..	0.0	–1.1
Private services	..	..	–2.8	..	..	..	–2.5
Public services	–5.0	–10.2	–2.1	..	..	..	–6.1
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–7.9	..	..	–36.1	–31.1
Other cereal grains	..	..	–8.0	..	..	–36.2	–31.2
Crops	..	..	–7.7	..	..	–36.0	–31.2
Forestry	..	..	–3.1	..	..	..	–2.9
Fisheries	..	..	–4.7	..	..	..	–4.6
Livestock for meat	..	..	–6.9	..	–0.6	0.0	–0.7
Other animal products	..	..	–6.6	..	–0.6	0.0	–1.1
Dairy cattle	..	..	–7.2	..	0.1	1.1	0.3
Wool	..	..	–4.6	..	2.0	2.7	2.1

.. No significant emissions from this sector.

A.39 *Domestic abatement and economic impacts after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2005*

Carbon charge		**US$/t 25**
Impacts relative to the reference case		
Change in domestic emissions	%	–2.56
GDP	%	–0.03
GNP	%	–0.04
Exchange rate	%	–0.02
Exports	%	–0.06
Imports	%	–0.11
Savings	%	–0.07
Investment	%	–0.04
Export price index	%	0.00
Import price index	%	0.00
Terms of trade	%	0.00

A.40 *Change in sectoral output, employment, exports, imports and supply prices after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2005, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–1.0	–1.6	8.0	..	–1.7
Oil	0.8	1.1	2.3	–1.1	–0.4
Gas	–2.1	–2.9	..	..	–2.7
Petroleum and coal products	–0.6	–0.7	0.7	–0.8	–0.2
Electricity	–1.7	–1.1	..	..	3.2
Iron and steel	–7.3	–7.2	–12.9	2.7	2.8
Nonferrous metals	–4.2	–4.2	–5.2	–0.9	1.0
Chemicals, rubber and plastic	–0.4	–0.4	–0.9	0.1	0.3
Clothing	0.3	0.3	0.6	–0.2	–0.1
Meat products	–0.1	–0.1	–0.2	0.0	0.0
Dairy products	0.3	0.2	0.3	–0.1	0.0
Food	0.2	0.2	0.5	–0.2	–0.1
Pulp, paper and publishing	0.2	0.2	0.6	–0.2	–0.1
Other wood products	0.0	0.0	0.1	–0.1	0.0
Minerals	–0.6	–0.7	1.0	–1.5	–0.2
Nonmetallic minerals	–0.1	–0.1	–0.6	0.2	0.1
Light manufacturing	0.1	0.1	0.3	–0.1	0.0
Other manufacturing	0.5	0.4	0.6	–0.1	–0.1
Construction	0.0	0.0	0.0	0.0	0.0
Trade and transport	0.0	0.0	0.4	–0.2	–0.1
Private services	0.1	0.1	1.0	–0.5	–0.3
Public services	0.1	0.1	0.7	–0.3	–0.2
Other services	0.1	0.0	..	..	–0.3
Rice	..	..	..	..	..
Wheat	0.1	0.1	..	0.0	0.0
Other cereal grains	0.1	0.1	0.2	0.0	0.0
Crops	0.2	0.2	0.2	0.0	0.0
Forestry	0.3	0.3	0.4	..	–0.1
Fisheries	0.1	0.2	–0.3	0.3	0.1
Livestock for meat	0.1	0.1	–0.1	0.2	0.1
Other animal products	0.0	0.0	0.0	0.1	0.0
Dairy cattle	0.2	0.3	..	..	0.0
Wool	0.1	0.1	0.1	0.1	0.0

.. Not a significant activity.

A.41 *Carbon market and economic impacts in New Zealand after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2010*

The carbon market		
Carbon charge	US$/t C	170.8
Net quota income	US$m	–601.8
Quota purchased	Mt CO_2 equiv.	12.9
Domestic abatement	Mt CO_2 equiv.	5.6
Economic impact relative to the reference case		
GDP	%	–0.24
GNP	%	–0.66
Exchange rate	%	–0.22
Exports	%	0.18
Imports	%	–0.42
Savings	%	–0.87
Investment	%	0.01
Export price index	%	0.01
Import price index	%	0.05
Terms of trade	%	–0.04

A.42 *Change in sectoral output, employment, exports, imports and supply prices after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2010, relative to the reference case*

	Output	Employment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–17.1	–22.4	–3.3	..	–15.1
Oil	–0.1	–0.4	0.5	–4.1	–4.5
Gas	–8.9	–11.3	..	..	–8.9
Petroleum and coal products	–2.7	–3.0	0.0	–2.4	–2.7
Electricity	–7.8	–4.3	..	..	23.7
Iron and steel	–25.8	–25.3	–44.2	12.5	18.9
Nonferrous metals	–12.8	–12.7	–19.6	–11.3	8.1
Chemicals, rubber and plastic	1.6	1.6	3.7	–0.6	–0.1
Clothing	0.8	0.8	2.1	–1.0	–0.3
Meat products	–2.0	–1.9	–3.6	1.1	0.4
Dairy products	1.4	1.3	1.6	0.8	0.0
Food	0.8	0.7	2.3	–0.4	–0.4
Pulp, paper and publishing	1.4	1.4	4.0	–1.1	–0.7
Other wood products	–0.8	–0.8	–2.1	1.1	0.4
Minerals	–0.5	–0.4	6.8	–5.8	0.3
Nonmetallic minerals	0.2	0.3	1.7	–1.3	1.0
Light manufacturing	–0.5	–0.6	–0.5	0.0	0.3
Other manufacturing	3.4	3.3	4.8	–1.0	–0.3
Construction	0.0	0.0	–0.6	–0.3	0.3
Trade and transport	0.0	–0.1	1.3	–0.6	–0.5
Private services	0.3	0.2	3.8	–1.4	–1.4
Public services	0.3	0.3	2.6	0.3	–1.0
Other services	–0.1	–0.3	..	..	–1.6
Rice	..	..	..	..	..
Wheat	0.1	0.5	..	0.0	0.1
Other cereal grains	0.1	0.5	0.2	0.4	0.1
Crops	0.3	0.8	0.4	0.1	0.2
Forestry	3.4	4.0	6.1	..	0.8
Fisheries	0.7	1.4	0.3	0.0	0.9
Livestock for meat	0.0	0.5	–1.2	1.4	0.5
Other animal products	0.0	0.4	0.0	0.3	0.5
Dairy cattle	1.1	1.5	..	..	0.6
Wool	2.7	3.3	5.5	0.3	0.8

.. Not a significant activity.

A.43 *Carbon market and economic impacts after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2015*

The carbon market		
Carbon charge	US$/t C	254.3
Net quota income	US$m	–1296.0
Quota purchased	Mt CO_2 equiv.	18.8
Domestic abatement	Mt CO_2 equiv.	9.7
Economic impact relative to the reference case		
GDP	%	–0.47
GNP	%	–1.80
Exchange rate	%	–0.48
Exports	%	0.96
Imports	%	–1.02
Savings	%	–2.27
Investment	%	–0.14
Export price index	%	–0.10
Import price index	%	0.13
Terms of trade	%	–0.23

A.44 *Change in sectoral output, employment, exports, imports and supply prices after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2015, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–20.9	–26.5	2.3	..	–16.7
Oil	0.0	–0.4	0.5	–5.8	–5.5
Gas	–12.5	–15.5	..	..	–11.4
Petroleum and coal products	–3.7	–4.0	0.9	–3.6	–3.2
Electricity	–11.9	–5.2	..	..	35.6
Iron and steel	–35.6	–34.8	–58.2	19.7	28.2
Nonferrous metals	–18.5	–18.4	–28.6	–14.6	11.8
Chemicals, rubber and plastic	2.6	2.6	5.9	–1.1	–0.1
Clothing	1.1	1.1	3.8	–2.0	–0.3
Meat products	–2.3	–2.2	–3.8	0.6	0.6
Dairy products	2.6	2.5	2.9	0.7	0.1
Food	1.6	1.5	4.2	–1.3	–0.5
Pulp, paper and publishing	2.6	2.5	6.9	–2.0	–1.2
Other wood products	–0.8	–0.7	–1.3	0.5	0.4
Minerals	–0.6	–0.5	10.5	–8.7	0.4
Nonmetallic minerals	0.4	0.5	3.2	–2.4	1.3
Light manufacturing	0.0	–0.1	1.1	–0.5	0.3
Other manufacturing	6.1	5.9	8.4	–2.1	–0.5
Construction	–0.2	–0.2	0.5	–1.1	0.4
Trade and transport	0.0	–0.1	3.0	–1.9	–0.7
Private services	0.4	0.3	7.4	–2.8	–2.2
Public services	0.0	0.0	5.8	–0.8	–1.7
Other services	–1.1	–1.4	..	..	–2.4
Rice	..	..	..	..	..
Wheat	0.5	1.2	..	0.1	0.4
Other cereal grains	0.4	1.1	0.3	0.8	0.4
Crops	0.3	1.2	0.5	0.4	0.6
Forestry	4.8	5.8	8.2	..	1.2
Fisheries	1.0	2.2	–0.9	1.1	1.7
Livestock for meat	0.2	1.1	–1.6	1.5	1.0
Other animal products	0.0	0.8	0.0	0.6	0.9
Dairy cattle	2.1	2.9	..	..	1.1
Wool	2.9	4.0	6.1	0.5	1.4

.. Not a significant activity.

A.45 *Carbon market and economic impacts after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2020*

The carbon market		
Carbon charge	US$/t C	367.2
Net quota income	US$m	–2536.9
Quota purchased	Mt CO_2 equiv.	25.5
Domestic abatement	Mt CO_2 equiv.	14.6
Economic impact relative to the reference case		
GDP	%	–0.84
GNP	%	–4.12
Exchange rate	%	–0.88
Exports	%	2.23
Imports	%	–2.06
Savings	%	–4.96
Investment	%	–0.45
Export price index	%	–0.35
Import price index	%	0.29
Terms of trade	%	–0.64

A.46 *Change in sectoral output, employment, exports, imports and supply prices after New Zealand unilaterally introduces a carbon charge prior to implementing the protocol with restricted coverage and no sinks at 2020, relative to the reference case*

	Output	Employment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–24.3	–29.9	8.2	..	–17.8
Oil	–0.1	–0.5	0.4	–7.6	–6.4
Gas	–17.0	–20.6	..	..	–13.5
Petroleum and coal products	–4.8	–5.0	2.7	–5.4	–3.6
Electricity	–17.2	–5.5	..	..	50.4
Iron and steel	–45.9	–44.7	–70.6	29.3	40.2
Nonferrous metals	–25.7	–25.4	–39.5	–18.0	16.8
Chemicals, rubber and plastic	4.0	4.1	8.9	–1.9	–0.1
Clothing	1.0	1.0	5.7	–3.7	–0.2
Meat products	–2.7	–2.6	–3.6	–0.5	0.9
Dairy products	4.0	4.0	4.5	0.4	0.4
Food	2.7	2.6	6.7	–2.7	–0.6
Pulp, paper and publishing	4.6	4.5	11.4	–3.3	–1.9
Other wood products	–0.5	–0.4	0.7	–1.0	0.3
Minerals	–0.7	–0.5	15.8	–12.7	0.5
Nonmetallic minerals	0.5	0.7	5.2	–4.1	1.7
Light manufacturing	1.2	1.1	4.3	–1.5	0.2
Other manufacturing	10.1	10.0	13.7	–4.0	–0.8
Construction	–0.6	–0.4	2.0	–2.4	0.5
Trade and transport	0.0	0.0	5.5	–4.0	–1.0
Private services	0.6	0.4	13.0	–5.1	–3.3
Public services	–0.7	–0.7	11.1	–2.7	–2.7
Other services	–3.4	–3.7	..	..	–3.5
Rice	..	..	..	..	..
Wheat	0.9	2.2	..	0.4	1.0
Other cereal grains	0.8	2.0	0.2	1.4	0.9
Crops	0.3	1.7	0.4	0.8	1.1
Forestry	6.5	7.9	10.3	..	1.6
Fisheries	1.6	3.5	–4.0	3.6	3.1
Livestock for meat	0.4	1.8	–2.6	1.9	1.6
Other animal products	–0.2	1.2	–0.2	0.9	1.5
Dairy cattle	3.4	4.7	..	..	1.9
Wool	3.2	4.7	6.8	0.7	2.0

.. Not a significant activity.

A.47 *Change in emissions in New Zealand when eastern Europe and the Russian Federation and the Ukraine do not participate in the protocol (scenario 12) at 2010, relative to the reference case*

	Coal combustion	Gas combustion	Petroleum and coal products combustion	Non combustion carbon dioxide	Methane	Nitrous oxide	Total emissions
	%	%	%	%	%	%	%
Coal	..	–54.8	–76.1	..	–62.0	..	–47.9
Oil	..	..	..	–6.7	–12.9	..	–7.2
Gas	..	..	..	–23.7	–28.8	..	–26.8
Petroleum and coal products	..	–44.3	–8.2	..	..	..	–37.9
Electricity	–73.5	–49.5	–94.9	..	..	..	–57.0
Iron and steel	–65.6	..	–65.6	..	..	..	–65.6
Nonferrous metals	–58.8	..	–29.9	–47.4	..	..	–52.2
Chemicals, rubber and plastic	..	–12.2	–1.3	..	..	..	–2.9
Clothing	..	..	..	..	..	..	..
Meat products	–46.2	..	..	..	..	..	–46.1
Dairy products	–86.9	..	–78.0	..	..	..	–85.8
Food	–38.5	..	4.5	..	..	..	–37.4
Pulp, paper and publishing	..	..	..	..	..	..	..
Other wood products	..	..	..	..	..	..	..
Minerals	..	..	..	..	..	..	..
Nonmetallic minerals	–28.2	..	21.3	–6.0	..	..	–15.1
Light manufacturing	..	..	..	..	..	..	..
Other manufacturing	..	..	..	..	..	..	..
Construction	..	–10.1	20.1	..	..	..	–9.7
Trade and transport	..	–0.4	–1.7	..	..	1.3	–1.6
Private services	..	..	–5.0	..	..	..	–4.5
Public services	–1.7	–7.5	7.9	..	..	..	–1.2
Other services	..	..	..	..	..	..	..
Rice	..	..	..	..	..	..	..
Wheat	..	..	–30.0	..	..	–49.1	–45.3
Other cereal grains	..	..	–28.7	..	..	–48.1	–44.3
Crops	..	..	3.4	..	..	–24.6	–20.0
Forestry	..	..	–9.1	..	..	..	–8.5
Fisheries	..	..	–10.2	..	..	..	–10.0
Livestock for meat	..	..	–39.7	..	–33.3	–30.2	–32.7
Other animal products	..	..	–45.4	..	–39.7	–36.9	–39.8
Dairy cattle	..	..	–71.8	..	–69.1	–66.6	–68.2
Wool	..	..	–68.5	..	–65.0	–63.3	–64.6

.. No significant emissions from this sector.

A.48 *Carbon market and economic impacts in New Zealand when eastern Europe and the Russian Federation and the Ukraine do not participate in the protocol at 2010*

The carbon market		
Carbon charge	US$/t C	576.9
Net quota income	US$m	7678.3
Net quota sales	Mt CO_2 equiv.	48.8
Domestic abatement	Mt CO_2 equiv.	67.1
Economic impact relative to the reference case		
GDP	%	–1.20
GNP	%	13.23
Exchange rate	%	2.49
Exports	%	–26.91
Imports	%	3.78
Savings	%	15.83
Investment	%	–0.36
Export price index	%	7.54
Import price index	%	1.31
Terms of trade	%	6.15

A.49 *Change in sectoral output, employment, exports, imports and supply prices in New Zealand when eastern Europe and the Russian Federation and the Ukraine do not participate in the protocol at 2010, relative to the reference case*

	Output	Employ-ment	Exports	Imports	Supply price
	%	%	%	%	%
Coal	–56.5	–61.0	–66.6	..	15.8
Oil	–6.7	–9.3	–8.4	–9.1	–8.1
Gas	–23.7	–27.6	..	..	–6.6
Petroleum and coal products	–7.9	–6.4	–0.4	–4.6	–5.7
Electricity	–18.5	–6.2	..	..	71.1
Iron and steel	–57.5	–56.1	–84.0	30.0	58.1
Nonferrous metals	–39.8	–38.7	–57.4	–25.0	23.9
Chemicals, rubber and plastic	–2.1	–1.0	2.9	–3.2	–0.3
Clothing	–35.8	–35.3	–64.1	27.5	15.9
Meat products	–19.3	–18.6	–43.3	0.8	22.4
Dairy products	–79.5	–79.3	–90.3	51.3	40.4
Food	–3.7	–2.8	–8.8	3.3	0.6
Pulp, paper and publishing	3.2	4.2	5.6	–1.5	–2.9
Other wood products	–3.2	–2.1	–15.0	9.9	0.4
Minerals	–5.2	–5.4	11.3	–16.7	–0.6
Nonmetallic minerals	–1.0	0.4	–6.2	–1.4	2.4
Light manufacturing	–5.9	–5.1	–14.1	3.1	–0.1
Other manufacturing	4.1	5.1	1.4	8.6	–1.3
Construction	–0.3	0.8	–11.3	4.8	0.6
Trade and transport	1.3	2.8	–7.1	10.2	–1.0
Private services	2.9	4.1	1.0	0.1	–4.6
Public services	14.6	15.0	–0.5	–6.2	–3.8
Other services	17.2	19.4	..	..	–4.5
Rice	..	..	..	..	..
Wheat	–17.5	–23.0	..	–13.5	–2.7
Other cereal grains	–16.0	–21.5	7.9	–15.3	–2.7
Crops	22.1	13.9	39.1	–21.0	–9.7
Forestry	2.3	3.0	4.5	..	–1.9
Fisheries	–0.6	–0.7	11.7	–9.9	–3.8
Livestock for meat	–30.2	–36.0	–26.5	–18.1	37.6
Other animal products	–36.9	–42.6	–36.9	–31.2	10.5
Dairy cattle	–66.6	–68.7	..	..	83.3
Wool	–63.3	–66.8	–97.7	45.5	94.5

.. Not a significant activity.

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