REPORT

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FINAL REPORT

Early action simulations

Results from G-Cubed

Prepared for

New Zealand Ministry for the Environment

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1 Introduction

This report

This report uses the G-Cubed model of the world economy to examine the impact of international measures to reduce carbon dioxide emissions. In particular, it examines the impact of using early taxes — that is, taxes put into place before international emissions trading commences — to try to minimise the adjustment costs of achieving the Kyoto Protocol target.

The framework

The underlying model framework used in this report is the same as that used in McKibbin and Pearce (1997, *Impacts on the New Zealand Economy of Commitments for Abatement of Carbon Dioxide Emissions*, CIE, November).

There are two key differences with the implementation of the model used in this report. First, the current version of G-Cubed has its database updated to 1996 and it now includes Europe and Canada as separate regions (table 1.1). The data update includes significantly revising the underlying data for Eastern Europe and the Former Soviet Union (EEFSU). The update also includes revising emissions coefficients throughout the model. The data update means that the model's 'jumping off' year is now 1996, rather than 1987 previously.

1.1 **Regions and sectors in G-Cubed**

Regions	***Sectors***
United States	Electric utiltities
Japan	Gas Utilities
Australia	Petroleum Refining
New Zealand	Coal Mining
Canada	Crude Oil and Gas Extraction
Europe	Mining
China	Agriculture
non oil LDCS	Forestry & Wood Products
EEFSU	Durable Manufacturing
OPEC	Non-Durable Manufacturing
	Transportation
	Services

The second difference is that the current version treats carbon emissions from oil and gas separately — previously these were accounted for jointly at the level of oil and gas extraction, now they are accounted for from petroleum refining and gas utilities. This means that changes in the composition of oil and gas use will result in compositional changes in emissions.

While McKibbin and Pearce (1997) set out the theoretical and structural details of G-Cubed, two particular features of the model are especially relevant for the early action context of its use in this report.

First, the model contains a mix of forward looking and backward looking agents (producers and consumers). In the standard model parameters, 30 per cent of agents are forward looking while the remainder are backward looking or liquidity constrained. Much of the early dynamics of the model — including the changes in real variables — resulting from the announcement of future policies arises through the interaction between these two types of agents.

Second, the model specifies the financial side of each economy and so is able to capture capital flows (as well as trade flows) between regions. Capital movements resulting from changes in expected and current rates of return are a key mechanism determining many of the model results.

Expectations in the model

Households base consumption decisions on wealth and current income. Wealth consists of current assets and expected future labour income (after tax). Changes in the future will effect both expectations of future labour income (for the forward looking agents), the real interest rate (which is used to discount future income) and the current value of capital assets. Thus changes in the future will affect consumption today as households attempt to smooth their consumption stream over their lives.

Firms make investment decisions based on both current profit and the expected future marginal returns to the investment. The marginal returns to investment depend on the future path of output, input costs and the interest rate used to discount to the present.

Asset markets value the future real returns to various activities. For example, equity markets reflect the expected future profits of firms. The valuations by the asset markets are used in the decisions by households and firms.

The scenarios

This report examines eight broad scenarios.

A. International emissions trading — commencing in January 2008 — in which all Annex B regions to meet their target commitments under the Kyoto Protocol.

B. A domestic tax for CO_2 emissions introduced from January 2001 to December 2007. The path for the tax is set to allow the tax to increase in equal increments to the permit price that results when international emissions trading commences in 2008.

C. As for scenario A, but with the ratio of liquidity constrained to forward looking agents is changed — for producers in New Zealand only — from 70/30 to 50/50 for the 5 energy sectors and the durable manufacturing sector.

D. As for scenario B but where New Zealand only implements the early domestic tax on CO_2 emissions from January 2001 to December 2007.

E. As for scenario B but where all Annex B countries implement a flat domestic tax on CO_2 emissions from January 2001 to December 2007. The rate of the tax is set at $US2.50 per tonne of carbon.

F. As for scenario B but where the target for New Zealand is +10% (instead of 0% relative to 1990) to take into account the level of non-CO_2 emissions during the commitment period, which are projected to be below 1990 levels. That is, this scenario includes both an early tax and an effective increase in New Zealand's initial allocation under the Kyoto Protocol.

G. As for scenario A, except that EEFSU is excluded from the emissions trading scheme.

H. As for scenario B, except that EEFSU is excluded from the emissiosn trading scheme (as in G).

2 *The revised baseline*

The baseline for the model is constructed in the same way as set out in McKibbin and Pearce (1997). That is, population and productivity changes are imposed on the model resulting in projections of growth and sectoral change and hence emissions. In the case of New Zealand, the domestic productivity of gas is reduced to reflect the closure of existing fields. The magnitude of this productivity decline is chosen to closely replicate official forecasts of emissions from gas.

Table 2.1 sets out the underlying productivity and population assumptions for New Zealand.

2.2 **Population and productivity changes in the baseline, New Zealand** per cent per year

	2000	2002	2004	2006	2008	2010	2012	2014	2016	2018	2020
Population	1.05	1.00	0.94	0.89	0.85	0.80	0.76	0.72	0.68	0.64	0.61
Sectoral productivity											
Electric utiltities	4.12	4.08	4.04	4.01	3.97	3.94	3.91	3.88	3.85	3.82	3.79
Gas Utilities	0.39	0.39	0.38	0.38	0.38	0.37	0.37	0.37	0.36	0.36	0.36
Petroleum Refining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coal Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Crude Oil and Gas Extraction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mining	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agriculture	1.83	1.81	1.80	1.78	1.76	1.75	1.74	1.72	1.71	1.70	1.68
Forestry & Wood Products	0.69	0.68	0.68	0.67	0.66	0.66	0.65	0.65	0.64	0.64	0.63
Durable Manufacturing	1.29	1.27	1.26	1.25	1.24	1.23	1.22	1.21	1.20	1.19	1.18
Non-Durable Manufacturing	2.93	2.90	2.87	2.85	2.82	2.80	2.78	2.76	2.73	2.71	2.70
Transportation	2.40	2.37	2.35	2.33	2.31	2.29	2.27	2.26	2.24	2.22	2.21
Services	1.20	1.19	1.18	1.17	1.16	1.15	1.14	1.13	1.12	1.11	1.11
Adjustment to gas utilities	-3.00	-3.00	-3.00	-3.00	-3.00	0.00	0.00	0.00	0.00	0.00	0.00

Data source: G-Cubed convergence model and UN population projections.

Under the baseline scenario, New Zealand's emissions are projected to increase from 7.3Mt (carbon) in 1996 to 8.8 Mt in 2010 (an increase of 20.5 per cent). Over the same period, GDP is projected to increase from NZ$95.8 billion to NZ$135.4 billion (an increase of 41 per cent).

Over the first commitment period, New Zealand's baseline emissions average 8.8 Mt, some 34 per cent higher than 1990 emissions. Were New

Zealand to achieve its Kyoto Protocol target without international trading, this would require an average reduction of 2.2 Mt, or 25 per cent, relative to baseline.

Chart 2.2 compares New Zealand's emission and GDP growth rate with that for other regions in the model. All countries have a close relationship between GDP growth and emissions growth, although emissions grow slower than GDP.

2.3 **Growth in emissions and GDP** 1996 to 2010

Region	***Emissions***	***GDP***
	%	%
USA	2.18	2.38
Japan	1.51	1.86
Australia	2.58	2.66
New Zealand	1.45	2.53
Canada	2.06	2.24
Europe	1.17	1.75
China	6.69	7.63
non oil LDCs	3.12	3.41
EEFSU	1.88	1.71

Source: G-Cubed model baseline.

In 1990, total Annex B emissions were 4027.4 Mt of carbon. This means that the Kyoto Protocol target requires emissions to be an average 3818 Mt over the first commitment period. Compared with average commitment period emissions in the baseline of 4731.5 Mt, this requires an average reduction of 19 per cent or 913.5 Mt.

Chart 2.3 summarises country shares in global emissions. The most notable feature of this is the rapid increase in the share of non-Annex B emissions.

2.4 **Country shares in global emissions**

	1996	***2000***	***2010***	***2020***
	%	%	%	%
USA	24.3	23.2	21.6	19.8
Japan	4.8	4.8	4.2	4.1
Australia	1.3	1.3	1.2	1.2
New Zealand	0.1	0.1	0.1	0.1
Canada	2.3	2.3	2.1	2.0
Europe	15.0	13.7	11.7	10.5
China	13.3	16.6	22.3	25.8
non oil LDCs	19.2	19.9	20.0	20.5
EEFSU	13.6	12.1	11.1	10.5
OPEC	6.1	5.9	5.7	5.6
	100.0	100.0	100.0	100.0

Source: G-Cubed model baseline.

3 The scenario results

Scenario A: emissions trading in Annex B

Table 3.1 summarises some key results for this scenario.

Achieving the Kyoto Protocol target for the first commitment period with international emissions trading results in a permit price of US$26.55 per tonne of carbon in 2008, increasing to US$31.55 per tonne in 2012. From 2012, the permit price continues to rise to US$44.55 per tonne in 2020 to ensure that total Annex B emissions remain at the first period commitment level[1].

Emissions changes

Chart 3.2 summarises the resulting emissions path for Annex B in total and for New Zealand, and table 3.3 summarises the Mt changes in emissions.

Average Annex B emissions in the commitment period are 3818Mt, and from 2012 to 2020 they average 3877Mt. For Annex B, emissions under Scenario A are roughly the same as baseline until 2008, when they begin to fall to meet the Kyoto Protocol target. For New Zealand, emissions begin to fall relative to baseline from around 2000.

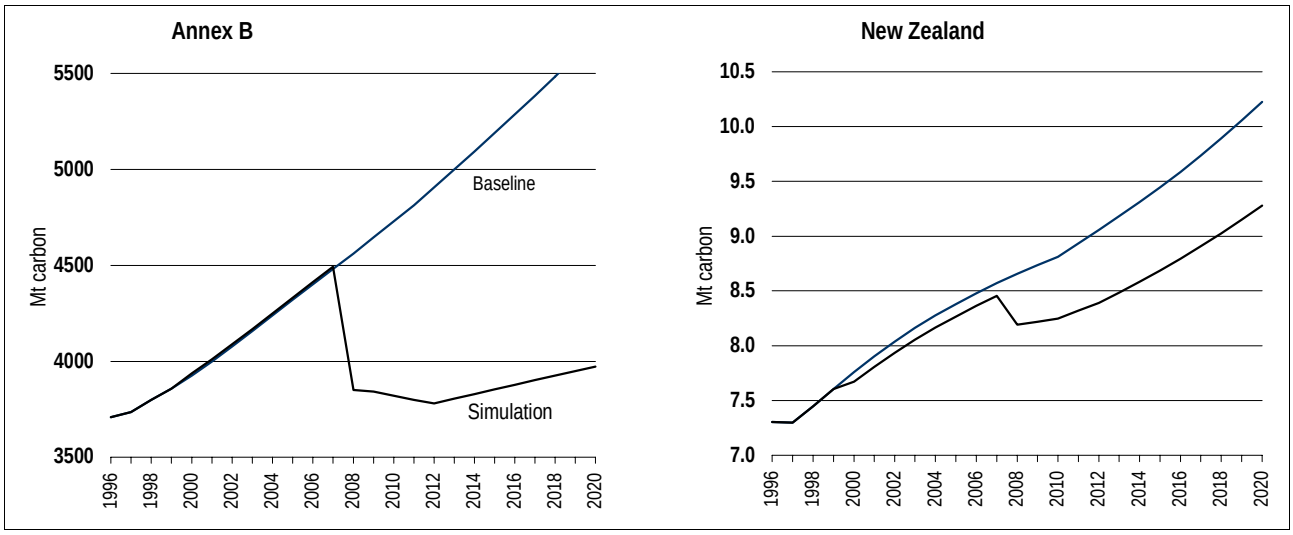
[1] The treatment of emissions trading in G-Cubed, combined with the fact that the Kyoto Protocol targets average emissions in 2008-12, means that there is some choice about the rate of increase of the permit price. This choice is made here in order to achieve a relatively smooth abatement path for Annex B regions in total.

3.1 **Scenario A: summary of key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	0	0	0	26.55	31.55	36.55	44.55
Reduction in GDP relative to baseline (per cent)								
USA	0.00	0.09	0.15	0.20	-0.06	-0.17	-0.25	-0.21
Japan	-0.05	-0.11	-0.13	-0.14	-0.15	-0.20	-0.21	-0.22
Australia	-0.04	-0.07	-0.09	-0.09	-0.61	-0.61	-0.67	-0.67
New Zealand	-0.04	-0.13	-0.16	-0.17	-0.26	-0.27	-0.26	-0.17
Canada	-0.18	-0.34	-0.33	-0.26	-0.82	-0.78	-0.78	-0.71
Europe	-0.02	-0.07	-0.11	-0.14	-0.33	-0.37	-0.40	-0.39
China	-0.04	-0.16	-0.19	-0.19	-0.27	-0.23	-0.21	-0.18
non oil LDCS	-0.02	0.13	0.22	0.29	0.35	0.39	0.40	0.34
EEFSU	0.10	0.24	0.37	0.51	-0.35	-0.42	-0.60	-0.59
Other results for New Zealand percentage change relative to baseline								
Real consumption	-0.96	-1.19	-1.23	-1.24	-1.22	-1.12	-0.91	-0.29
Government spending	-0.14	-0.12	-0.10	-0.09	-0.22	-0.25	-0.27	-0.35
Private investment	-1.01	-0.82	-0.68	-0.50	-0.30	-0.43	-0.46	-0.52
Exports	1.48	1.39	1.24	1.13	0.52	0.32	0.01	-0.50
Imports	-0.79	-0.94	-0.98	-0.98	-1.33	-1.47	-1.55	-1.62
Nominal exchange rate NZ$/$US	5.35	5.63	5.57	5.41	4.75	4.52	4.34	4.53
Long term interest rate	-0.20	-0.43	-0.59	-0.83	-1.02	-0.88	-0.69	-0.17
Aggregate employment	-0.03	-0.15	-0.15	-0.12	-0.26	-0.24	-0.19	-0.02

Data source: G-Cubed model simulations

3.2 **Scenario A: carbon emissions** Annex B total and New Zealand



Data source: G-Cubed model simulation.

The average abatement for Annex B countries is 915 Mt over the commitment period. New Zealand's average abatement is 0.6 Mt — only about 30 per cent of what would be required without emissions trading. Thus, New Zealand is a net purchaser of permits. Supplementarity caps (as

suggested by the EU), would clearly have a significant impact on New Zealand's abatement under emissions trading.

3.3 **Scenario A: summary of emissions changes relative to baseline** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	8.6	11.3	12.6	13.4	-233.7	-307.0	-384.6	-595.5	-5,447.9
Japan	-3.4	-3.8	-4.1	-4.2	-16.1	-20.5	-24.9	-38.1	-391.4
Australia	-0.4	-0.4	-0.4	-0.4	-12.4	-15.3	-18.6	-27.8	-268.6
New Zealand	-0.1	-0.1	-0.1	-0.1	-0.5	-0.6	-0.7	-0.9	-10.2
Canada	-2.3	-3.0	-3.2	-3.3	-24.8	-30.8	-37.3	-57.0	-562.5
Europe	-8.3	-10.2	-11.7	-12.9	-67.8	-84.9	-103.2	-155.6	-1,569.6
China	-3.6	-5.3	-5.5	-5.5	-6.4	-6.4	-7.0	-10.2	-142.3
non oil LDCS	16.2	21.7	24.7	26.6	49.3	52.2	55.6	61.3	911.8
EEFSU	17.4	17.8	17.7	17.3	-354.3	-450.6	-557.3	-845.9	-7,837.1
World	24.2	27.9	30.0	30.8	-666.8	-863.8	-1,078.0	-1,669.8	-15,317.8
Annex B	11.6	11.5	10.8	9.7	-709.6	-909.6	-1,126.6	-1,720.9	-16,087.4

Data source: G-Cubed model simulation.

Table 3.3 also shows the cumulative abatement between 1999 and 2020. For all Annex B regions it amounts to 16 087 Mt. Around 30 per cent of this (4480 Mt) takes place in or before 2012.

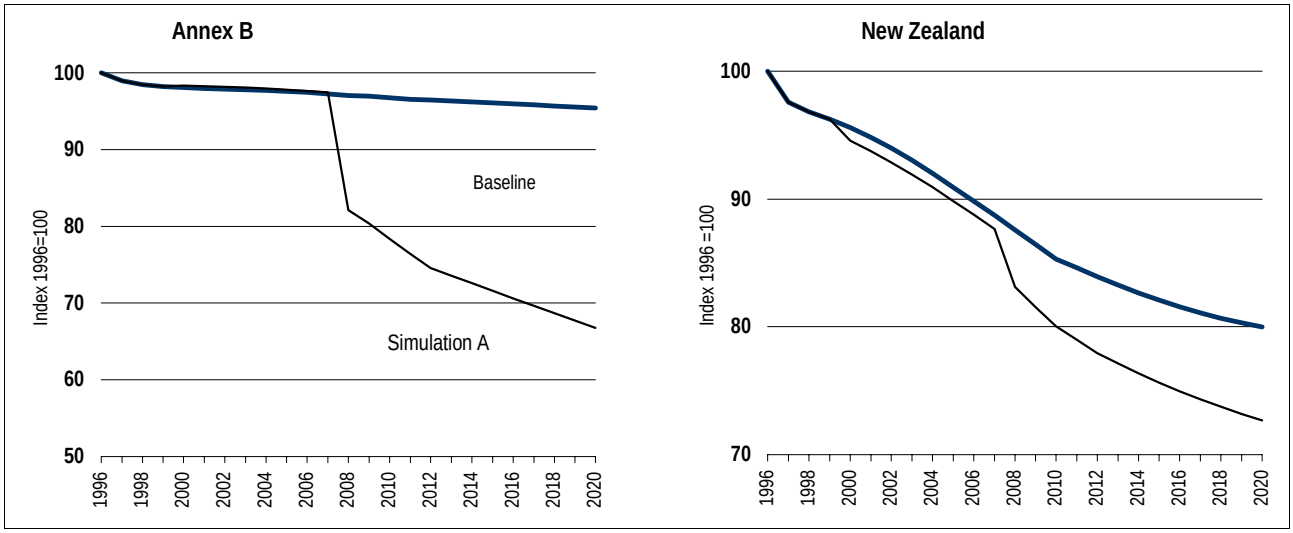
It is interesting to note from table 3.3 that for some regions (including Australia, New Zealand, Canada and Europe), some small amount of abatement takes place before emission trading commences in 2008. For others (USA, Japan and EEFSU) emissions increase before 2008.

For New Zealand, cumulative abatement to 2007 is 0.85 Mt, 8.3 per cent of cumulative abatement to 2020 and 23 per cent of cumulative abatement to 2012. An alternative way of looking at this is that the average early abatement (in each year before 2008) expressed in Mt relative to the baseline is around 17 per cent of the average abatement in the commitment period 2010 (0.1 Mt compared with 0.6 Mt).

Emissions intensity

Another way of looking at abatement is through emissions intensity (defined as emissions per dollar of GDP). Chart 3.4 summarises emission intensity for Annex B in total and for New Zealand. For Annex B, the aggregate emission intensity does not begin to decline until 2008. This is due to compositional effects — while the intensity for some regions increases, for others it declines, leading to no net effect until 2008. For New Zealand, emissions intensity begins to decline in 2000.

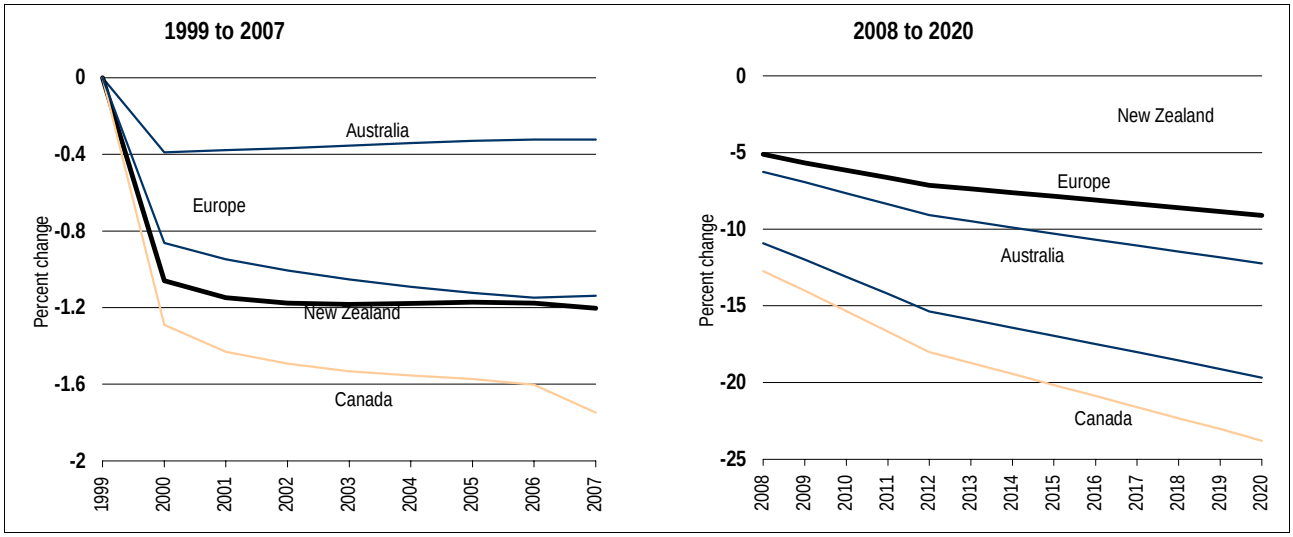
3.4 Scenario A: emissions intensity Annex B total and New Zealand



Data source: G-Cubed model simulation

Chart 3.5 shows the changes in emission intensity relative to baseline for selected Annex B regions. Before 2008, New Zealand's reduction in emission intensity relative to baseline is in between that for Europe, Australia and Canada. After 2008, New Zealand's reduction is below that for these other countries.

3.5 Scenario A: change in emission intensity relative to baseline



Data source: G-Cubed model simulation

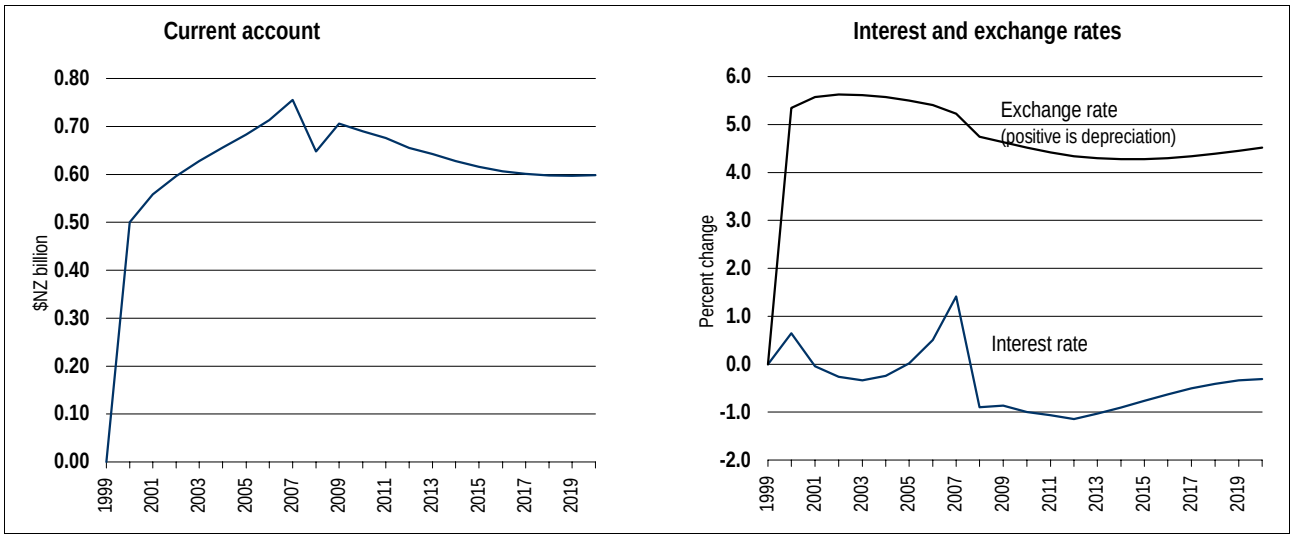
A number of factors combine to determine the amount of early abatement, each essentially arising through the forward-looking behaviour of agents in the model. Producers and consumers realize there will be a higher price of carbon — and therefore energy — in the future and begin various

adjustments early so as to minimise (given technology, preferences and adjustment costs) the effect of the higher carbon and energy prices over the full life of the simulation.

One of the key adjustments is in the allocation of capital between regions. The expectation of higher energy prices and the subsequent reduction in rates of return leads to a capital outflow from most regions to the United States and Japan. For New Zealand, the capital outflow can be seen from the increased surplus on the current account and the subsequent depreciation of the exchange rate (chart 3.6). Note that the capital outflow and the depreciation happen as soon as emission trading is announced (in 2000). The capital outflow is associated with a reduction in GDP, and the subsequent income loss explains some of the reduction in emissions.

The capital outflow is, in fact, determined by the interaction between forward looking and backward looking agents in the model. The liquidity constrained backward looking agents overreact somewhat to the initial reduction in spending by the forward-looking agents. This further accentuates the reduction in activity, lowers returns to capital and contributes to the capital outflow. The importance of this mechanism will be seen further in scenario C.

3.6 **Scenario A: current account, interest rates and exchange rates**



Data source: G-Cubed model simulation

In addition, producers in trying to maximise the present value of their profit stream begin to make some substitutions in production towards less energy intensive activities. There are a number of tradeoffs involved here. On the one hand, discounting means that it is better to incur costs in the future than today. On the other hand, the stream of profits will be maximised by attempting to minimise adjustment costs. The amount of

early action will be determined by the relative magnitude of these effects. It will also be determined by a general equilibrium interaction between the various agents in the model. As 2008 approaches, the agents will want to begin reinvesting, but this results (worldwide) in a spike in interest rates immediately before the emissions trading commences (this spike in the case of New Zealand in shown in chart 3.6). This increase in interest rates modifies the desired change in investment, limiting the amount of early abatement to some extent.

Economywide emissions intensity also declines because of a compositional change within the economy to less energy intensive activities. That is, there is a reduction in the share of energy intensive activities relative to less energy intensive activities.

Note that as far as agents in the model are concerned, the implementation of emissions trading in the future is fully credible. The forward looking agents actually *know* that it is implemented in the future and also know the future effect on prices relevant to their decisions. This is clearly in contrast to the real world, where first, many forward looking agents may actually expect the Kyoto Protocol *not* to come into force and second, even if they expect it to come into force, they do not know with certainty what effect it will have on prices. Under Kyoto Protocol style international emissions trading, we have no idea about the future price until trading commences.

Other macro effects

The abatement results in reductions in GDP (relative to baseline) for all Annex B regions. The greatest losses are in Australia and Canada, followed by Europe and New Zealand, and then USA and Japan. New Zealand's GDP declines by 0.27 per cent in 2010 and by 0.17 per cent in 2020. New Zealand's real consumption also declines by up to 1.2 per cent.

Table 3.2 presents the GDP changes for each region in billions of 1996 US dollars. The loss to New Zealand is US$0.25 billion in 2010. The cumulative loss for New Zealand between 1999 and 2020 (relative to the baseline and discounted at 5 per cent real) is US$2.04 billion. The cumulative loss for all Annex B regions is US$685.8 billion.

Appendix table A.1 shows real consumption changes for each region in billions of 1996 US dollars. The loss to New Zealand is $0.59 billion in 2010. The cumulative loss in real consumption for New Zealand between 1999 and 2020 (relative to the baseline and discounted at 5 per cent real) is US$6.01 billion. The cumulative loss for all Annex B regions is US$611 billion.

3.7 **Scenario A: summary of GDP changes relative to baseline** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	0.05	8.50	14.95	21.10	-6.11	-19.18	-29.43	-29.9	-77.64
Japan	-2.60	-5.65	-7.06	-7.80	-8.69	-12.52	-13.82	-16.9	-121.75
Australia	-0.18	-0.36	-0.47	-0.47	-3.40	-3.56	-4.10	-4.8	-26.74
New Zealand	-0.03	-0.10	-0.13	-0.14	-0.23	-0.25	-0.25	-0.2	-2.04
Canada	-1.27	-2.51	-2.54	-2.09	-6.93	-6.93	-7.19	-7.7	-55.99
Europe	-2.57	-7.08	-12.13	-16.43	-39.94	-45.85	-51.68	-57.9	-365.90
China	-0.42	-2.19	-3.06	-3.56	-5.63	-5.30	-5.45	-6.4	-48.79
non oil LDCS	-0.83	5.73	10.85	14.88	19.48	22.63	24.91	27.1	200.15
EEFSU	1.77	4.35	7.11	10.10	-7.15	-8.97	-13.34	-15.7	-35.75
World	-6.06	0.69	7.52	15.59	-58.59	-79.94	-100.36	-112.5	-534.45
Annex B	-4.82	-2.85	-0.27	4.27	-72.44	-97.27	-119.82	-133.2	-685.81

Data source: G-Cubed model simulations.

The trade effects for New Zealand are largely determined by the effect of capital flows on the exchange rate. Export increase and imports decline. While the model assumes that New Zealand is able to find markets for its exports, the presence of quotas or other quantitative restrictions in the international market would influence the composition of these exports.

Employment declines by up to 0.26 per cent in 2008, after which employment begins to return to baseline as real wages adjust.

Industry effects

Table 3.8 summarises the changes in sectoral output and investment. Both of these decline for most sectors, and the decline begins early. For the forestry and wood products sector, output actually increases throughout the simulation period. This results first from the fact that forestry is not an energy intensive activity and so is not affected by the increase in the price of fuels and second from the devaluation of New Zealand's exchange rate, allowing the sector to sell more on international markets.

3.8 **Scenario A: summary of industry effects** percentage change relative to baseline

	2000	2002	2004	2006	2008	2010	2012	2020
Change in production relative to baseline								
Electric utiltities	-0.22	-0.35	-0.41	-0.43	-0.57	-0.60	-0.60	-0.52
Gas Utilities	-0.36	-0.50	-0.57	-0.64	-9.54	-13.29	-15.90	-21.71
Petroleum Refining	-0.76	-0.94	-0.99	-0.99	-3.64	-4.38	-5.03	-6.29
Coal Mining	-0.50	-0.72	-0.78	-0.77	-5.97	-7.00	-8.08	-10.89
Crude Oil and Gas Extraction	-0.04	-0.10	-0.13	-0.16	-0.88	-1.39	-1.85	-2.99
Mining	-0.34	-0.37	-0.35	-0.31	-0.68	-0.81	-0.92	-1.12
Agriculture	-0.34	-0.38	-0.37	-0.33	-0.48	-0.52	-0.53	-0.51
Forestry & Wood Products	0.59	0.93	1.03	1.06	0.97	0.82	0.69	0.39
Durable Manufacturing	-0.06	-0.03	0.01	0.06	-0.05	-0.11	-0.18	-0.31
Non-Durable Manufacturing	0.04	-0.10	-0.12	-0.11	-0.42	-0.46	-0.52	-0.53
Transportation	-0.13	-0.23	-0.25	-0.24	-0.40	-0.43	-0.43	-0.38
Services	-0.11	-0.27	-0.34	-0.36	-0.42	-0.41	-0.36	-0.12
Change in investment relative to baseline								
Electric utiltities	-1.82	-1.91	-1.85	-1.71	-1.54	-1.51	-1.39	-1.24
Gas Utilities	-0.78	-0.95	-1.37	-1.82	-7.73	-8.88	-10.02	-11.72
Petroleum Refining	-6.25	-6.37	-6.27	-6.39	-30.18	-32.39	-35.01	-44.40
Coal Mining	-4.73	-5.39	-6.33	-7.63	-12.95	-14.09	-15.27	-19.71
Crude Oil and Gas Extraction	-0.34	-0.56	-0.73	-0.84	-7.08	-7.99	-8.88	-10.14
Mining	-1.48	-1.32	-1.29	-1.20	-1.29	-1.62	-1.91	-2.59
Agriculture	-0.70	-0.87	-0.89	-0.80	-0.45	-0.60	-0.65	-0.70
Forestry & Wood Products	11.45	5.93	3.74	3.16	1.48	0.72	0.40	0.38
Durable Manufacturing	-0.27	-0.03	0.07	0.23	0.31	0.06	-0.15	-0.57
Non-Durable Manufacturing	-0.04	-0.33	-0.46	-0.50	-0.85	-0.93	-1.08	-1.23
Transportation	-1.56	-1.64	-1.47	-1.22	-1.28	-1.29	-1.23	-1.16
Services	-1.79	-1.81	-1.52	-1.20	-1.14	-0.91	-0.56	-0.05

Data source: G-Cubed model simulation.

Comparison with previous results

Scenario A is similar to scenario G presented in McKibbin and Pearce (1997). While this old scenario G had a more stringent abatement target (10 per cent below baseline for Annex B regions) it is interesting to compare the pattern of abatement between the current scenario A and the old scenario G.

Table 3.9 presents a comparison. Key points to note are as follows.

- The baseline growth in emissions is different between the current results and previous results (first two columns of table 3.4). In particular stronger growth is now projected for the US and (in the form of lower negative growth) for EEFSU.

- Under emissions trading, the change in emissions relative to baseline is now considerably greater for EEFSU, but smaller for the other abating regions than was the case previously.
- In terms of the share of total abatement (that is, the country shares in hitting the total Annex B target), in the current scenario A, a significantly greater share of abatement is undertaken by EEFSU. Under the new scenario A, over half of the abatement is accounted for by EEFSU compared with only 14 per cent previously.

Essentially, updated information on EEFSU implies that their marginal cost of abatement is lower than previously, so they abate more. In contrast, the marginal cost of abatement for the US is higher, so it abates less.

The importance of the amount of abatement undertaken by EEFSU is examined in scenario G below.

3.9 **Comparison of scenario A with old scenario G**

	Emissions growth 1990 to 2010		Emissions relative to baseline in 2010		Share of total abatement in 2010	
	Previous results	Current results	Previous results (scenario G)	Current results (scenario A)	Previous results (scenario G)	Current results (scenario A)
	% pa	% pa	%	%	%	%
USA	1.20	2.79	-50	-16	60	34
Japan	2.67	2.92	-25	-5	8	2
Australia	2.43	3.13	-30	-14	3	2
New Zealand	1.58	2.24	-14	-6	0.09	0.06
Other OECD	1.33	1.64	-16	-9	15	13
China	3.04	8.30	na	na	na	na
Non oil LDCs	3.20	5.05	na	na	na	na
EEFSU	-2.43	-0.02	-27	-45	14	50
Annex I (B)	**0.56**	**2.98**	**-32**	**-19**	**100**	**100**

Data source: G-Cubed model simulations.

Scenario B: early domestic taxes then emissions trading

Table 3.10 presents the key results from this scenario. In this case, an early tax is introduced in 2001. The early tax is chosen so that it can be smoothly increased, in equal increments, to the actual permit price in 2008.

With the early tax, the Annex B Kyoto target is met with a slightly lower permit price in the commitment period than was the case for scenario A.

The early tax results in GDP losses relative to scenario A before 2008, then gains relative to scenario A in 2008 and after. However, as table 3.11 shows, the future gains do not offset the early losses. For New Zealand, the cumulative relative loss is US$0.06 billion. For the all Annex B regions the

cumulative loss is US$84.4 billion. This story is slightly different for real consumption where there is a small net gain for New Zealand (table A.2).

3.10 **Scenario B: Key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	6.48	12.95	19.43	25.9	30.9	35.9	43.9
Reduction in GDP relative to scenario A (per cent)								
USA	0.02	-0.05	-0.13	-0.22	-0.02	0.04	0.07	0.05
Japan	0.00	-0.01	-0.03	-0.05	-0.05	0.00	0.00	0.01
Australia	0.02	-0.10	-0.20	-0.31	0.11	0.06	0.07	0.02
New Zealand	0.01	-0.03	-0.05	-0.08	0.01	0.03	0.04	0.01
Canada	0.05	-0.11	-0.22	-0.34	0.17	0.12	0.09	0.01
Europe	0.01	-0.02	-0.06	-0.10	0.03	0.02	0.03	0.01
China	0.01	0.00	-0.01	-0.02	0.04	0.00	-0.01	-0.01
non oil LDCS	0.00	0.01	0.03	0.04	0.03	0.02	0.01	0.00
EEFSU	0.06	-0.14	-0.34	-0.58	0.12	0.09	0.14	0.09
Other results for New Zealand - percentage change relative to scenario A								
Real consumption	-0.13	-0.19	-0.19	-0.08	0.08	0.18	0.18	0.03
Government spending	-0.01	-0.05	-0.08	-0.11	0.00	0.00	-0.01	-0.01
Private investment	0.04	0.08	0.06	-0.04	-0.20	-0.04	-0.01	0.01
Exports	0.16	0.06	-0.08	-0.31	-0.05	-0.14	-0.08	0.01
Imports	-0.03	-0.14	-0.26	-0.38	-0.11	-0.02	0.01	-0.01
Nominal exchange rate NZ$/$US	0.34	0.27	0.15	0.00	0.29	0.24	0.22	0.20
Long term interest rate	-0.56	-0.57	-0.44	-0.10	0.26	0.29	0.24	0.01
Aggregate employment	0.02	-0.04	-0.08	-0.12	0.06	0.08	0.08	0.01

Data source: G-Cubed model simulation.

3.11 **Scenario B: change in GDP relative to scenario A** $US billion

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	1.76	-4.52	-12.60	-23.04	-2.28	4.95	8.92	6.44	-27.40
Japan	0.00	-0.61	-1.55	-2.58	-2.99	-0.26	0.16	0.42	-8.13
Australia	0.10	-0.47	-1.03	-1.67	0.64	0.35	0.40	0.12	-3.32
New Zealand	0.01	-0.02	-0.04	-0.07	0.01	0.03	0.04	0.01	-0.06
Canada	0.38	-0.80	-1.67	-2.78	1.45	1.07	0.81	0.09	-4.43
Europe	1.26	-2.70	-6.83	-11.69	3.40	3.08	3.35	1.12	-21.59
China	0.18	0.02	-0.11	-0.44	0.92	0.08	-0.23	-0.29	-3.08
non oil LDCS	-0.05	0.56	1.36	2.30	1.54	1.09	0.62	0.12	10.78
EEFSU	1.08	-2.56	-6.51	-11.62	2.52	1.89	3.08	2.26	-19.48
World	4.71	-11.09	-29.00	-51.59	5.22	12.27	17.15	10.31	-76.70
Annex B	4.59	-11.67	-30.24	-53.45	2.76	11.11	16.76	10.47	-84.40

Data source: G-Cubed model simulation.

Table 3.12 shows the change in emissions under scenario B relative to scenario A. The early tax clearly results in significant early abatement.

Abatement is greater each year before 2008, as is cumulative abatement between 1999 and 2020.

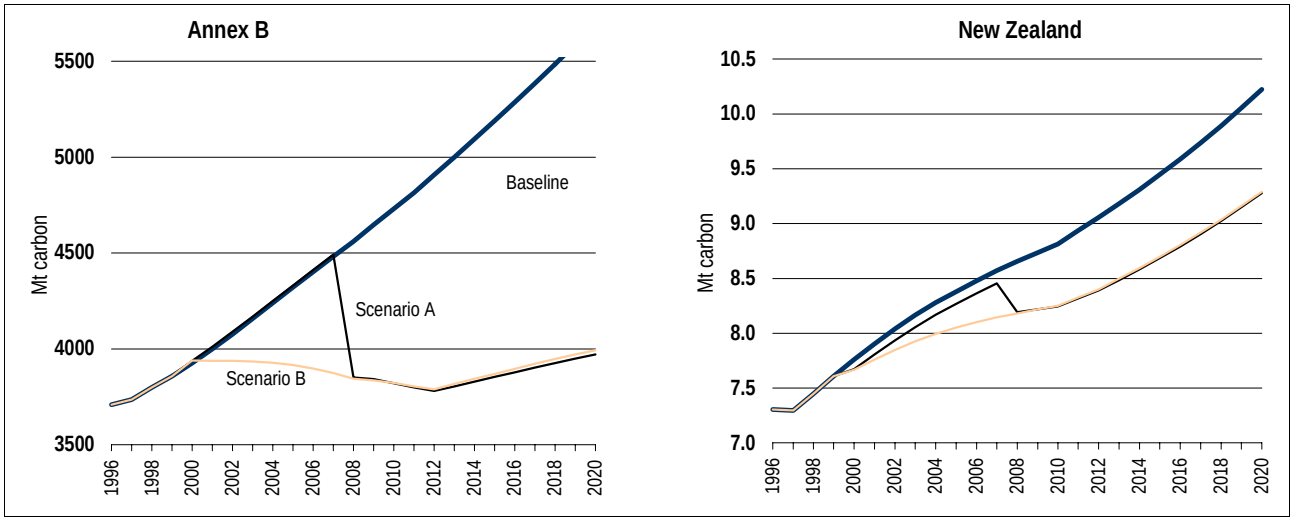
3.12 **Scenario B: change in emissions relative to scenario A** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	1.0	-51.8	-111.8	-179.1	-6.3	-0.7	3.1	9.3	-754.5
Japan	0.0	-2.6	-5.6	-9.1	-1.2	-0.6	-0.3	0.2	-43.5
Australia	0.0	-2.5	-5.3	-8.3	0.3	0.2	0.2	0.3	-34.4
New Zealand	0.0	-0.1	-0.2	-0.3	0.0	0.0	0.0	0.0	-1.1
Canada	-0.1	-4.7	-9.9	-15.5	-0.4	-0.3	-0.1	0.4	-70.6
Europe	-0.1	-11.7	-24.9	-39.8	-2.5	-1.6	-0.7	0.9	-186.4
China	0.0	0.0	-0.1	-0.6	-0.2	-0.8	-0.9	-0.5	-13.9
non oil LDCS	0.4	5.0	9.4	13.9	-3.2	-2.2	-1.6	0.3	51.5
EEFSU	0.6	-77.9	-164.9	-261.6	2.6	3.7	6.6	11.7	-1,089.6
World	1.8	-146.2	-313.2	-500.3	-10.9	-2.2	6.3	22.7	-2,142.3
Annex B	1.4	-151.2	-322.5	-513.6	-7.5	0.8	8.8	22.9	-2,180.0

Data source: G-Cubed model simulation.

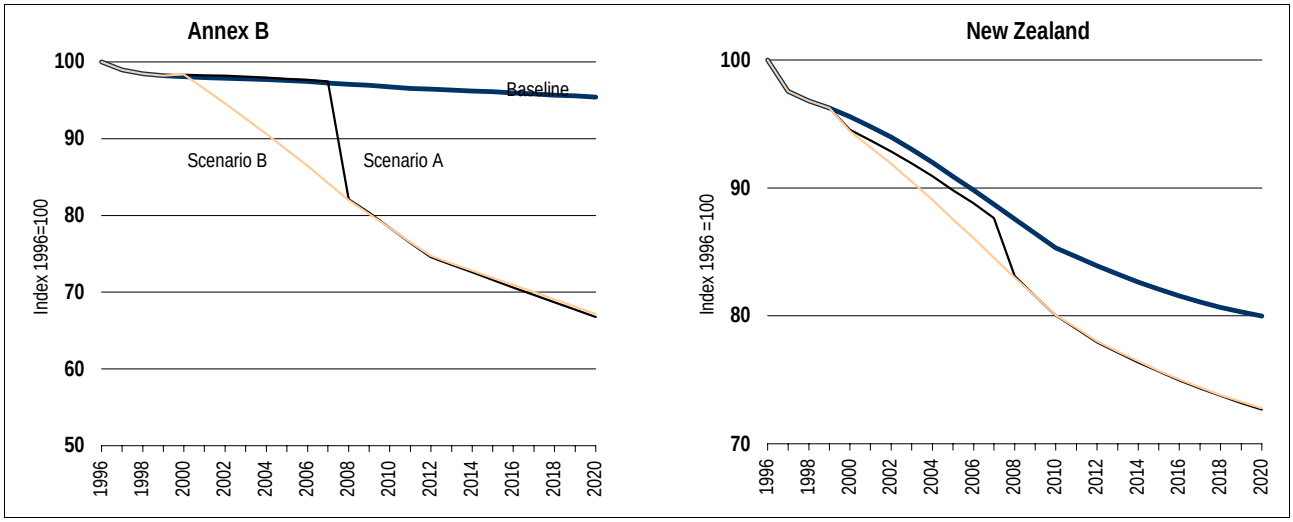
However, after 2008, abatement is not significantly different from what was the case in scenario A. Chart 3.13 illustrates this with the emissions path for Annex B and for New Zealand. In each case, emission decline early under scenario B, but by 2008 return to their scenario A path. Chart 3.14 shows the effect of the early tax on emission intensity. Again, emission intensity declines early, but returns to the scenario A level by 2008.

3.13 **Emissions Annex B and New Zealand**



Data source: G-Cubed model simulation.

3.14 **Emission intensity: scenario A and B**



Data source: G-Cubed model simulation

As before, several factors explain the change in emission intensity. The early tax provides agents additional incentive to adjust before 2008. This manifests itself in greater capital outflow initially and a greater initial fall in consumption. Production and investment changes, resulting in a reduction in emissions intensity before 2008. However, the early tax does not give agents additional information about outcomes from 2008, and so they are able to return to their original optimal activities (the same as in scenario A) in order to meet the Kyoto Protocol targets.

It is interesting to note that while the particular early tax chosen in this simulation does not lower the costs of achieving the Kyoto Protocol target, it does slightly lower the costs of a given total level of cumulative abatement. For example, under scenario A, the cumulative GDP cost for the cumulative abatement (for all Annex B) is US$42 per tonne (US$685.8 billion divided by 16 087 Mt, from tables 3.7 and 3.3 respectively). However, under scenario B, the cumulative GDP cost for the cumulative abatement (this time defined relative to scenario A) is US$38 per tonne.

For New Zealand, earlier abatement leads to a reduction in the cost of a cumulative abatement of 7 per cent relative to scenario A. Thus, this particular early tax does not make the Kyoto Protocol cheaper, but it does make the total cumulative cost of cumulative abatement cheaper.

This result highlights a feature of the Kyoto Protocol. By specifying a target over a particular period (2008 to 2012), the Protocol makes it difficult to minimise costs through early action. If the Protocol were to focus on

cumulative emissions, then it would automatically contain more rewards for early action.

Scenario C: more forward looking in New Zealand

This simulation involves changing some of the key parameter settings in the model. In particular, a greater proportion of New Zealand producers (in the five energy sectors durable manufacturing) are made forward looking. With this change, emission trading is introduced in 2008 as under scenario A. In what follows, results are presented relative to a new baseline constructed with the alternate parameter set.

Compared with scenario A, the effects of permit trading on New Zealand are now smaller. Table 3.15 shows that the loss in GDP, consumption and so on are smaller (relative to baseline) than was the case for scenario A.

Comparing table 3.15 with table 3.1 shows a slightly smaller loss in GDP in most years and similarly smaller losses in real consumption. This can also be seen by comparing table 3.17 with table 3.7 where the cumulative loss in GDP is $1.9 billion in scenario C but $2.04 billion in scenario A.

Comparing table A.3 with table A.1 shows a similar pattern for the dollar loss in real consumption — it is slightly smaller with more forward looking behaviour.

3.15 **Scenario C: summary of key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	0	0	0	26.55	31.55	36.55	44.55
Reduction in GDP relative to baseline (per cent)								
USA	0.00	0.09	0.15	0.20	-0.06	-0.17	-0.25	-0.21
Japan	-0.05	-0.11	-0.13	-0.14	-0.15	-0.20	-0.21	-0.22
Australia	-0.04	-0.07	-0.09	-0.09	-0.61	-0.61	-0.67	-0.67
New Zealand	-0.03	-0.12	-0.16	-0.16	-0.25	-0.26	-0.24	-0.16
Canada	-0.18	-0.34	-0.33	-0.26	-0.82	-0.78	-0.78	-0.71
Europe	-0.02	-0.07	-0.11	-0.14	-0.33	-0.37	-0.40	-0.39
China	-0.04	-0.16	-0.19	-0.19	-0.27	-0.23	-0.21	-0.18
non oil LDCS	-0.02	0.13	0.22	0.29	0.35	0.39	0.40	0.34
EEFSU	0.10	0.24	0.37	0.51	-0.35	-0.42	-0.60	-0.59
Other results for New Zealand percentage change relative to baseline								
Real consumption	-0.91	-1.14	-1.17	-1.18	-1.16	-1.06	-0.86	-0.30
Government spending	-0.13	-0.12	-0.10	-0.09	-0.22	-0.24	-0.27	-0.34
Private investment	-0.99	-0.79	-0.65	-0.49	-0.24	-0.36	-0.39	-0.46
Exports	1.42	1.33	1.19	1.09	0.47	0.28	-0.02	-0.49
Imports	-0.79	-0.92	-0.97	-0.97	-1.31	-1.45	-1.53	-1.59
Nominal exchange rate NZ$/$US	5.28	5.56	5.51	5.35	4.69	4.47	4.31	4.57
Long term interest rate	-0.19	-0.40	-0.55	-0.76	-0.94	-0.79	-0.61	-0.14
Aggregate employment	-0.03	-0.14	-0.15	-0.11	-0.25	-0.23	-0.19	-0.02

Data source: G-Cubed model simulation

Table 3.16 summarises the emissions changes relative to baseline. Comparing these with table 3.3 shows that these are the same for all regions but slightly smaller for New Zealand.

3.16 **Scenario C: summary of emission changes relative to baseline** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	8.6	11.3	12.6	13.4	-233.7	-307.0	-384.6	-595.5	-5,447.9
Japan	-3.4	-3.8	-4.1	-4.2	-16.1	-20.5	-24.9	-38.1	-391.4
Australia	-0.4	-0.4	-0.4	-0.4	-12.4	-15.3	-18.6	-27.8	-268.6
New Zealand	-0.1	-0.1	-0.1	-0.1	-0.5	-0.6	-0.7	-0.9	-10.1
Canada	-2.3	-3.0	-3.2	-3.3	-24.8	-30.8	-37.3	-57.0	-562.5
Europe	-8.3	-10.2	-11.7	-12.9	-67.8	-84.9	-103.2	-155.6	-1,569.7
China	-3.6	-5.3	-5.5	-5.5	-6.4	-6.4	-7.0	-10.2	-142.4
non oil LDCS	16.2	21.7	24.7	26.6	49.3	52.2	55.6	61.3	911.8
EEFSU	17.4	17.8	17.7	17.3	-354.3	-450.6	-557.3	-845.9	-7,837.2
World	24.2	27.9	30.0	30.8	-666.8	-863.8	-1,078.0	-1,669.8	-15,317.9
Annex B	11.6	11.5	10.8	9.7	-709.6	-909.6	-1,126.6	-1,720.9	-16,087.3

Data source: G-Cubed model simulation.

Table 3.17 summarises the loss in GDP relative to baseline.

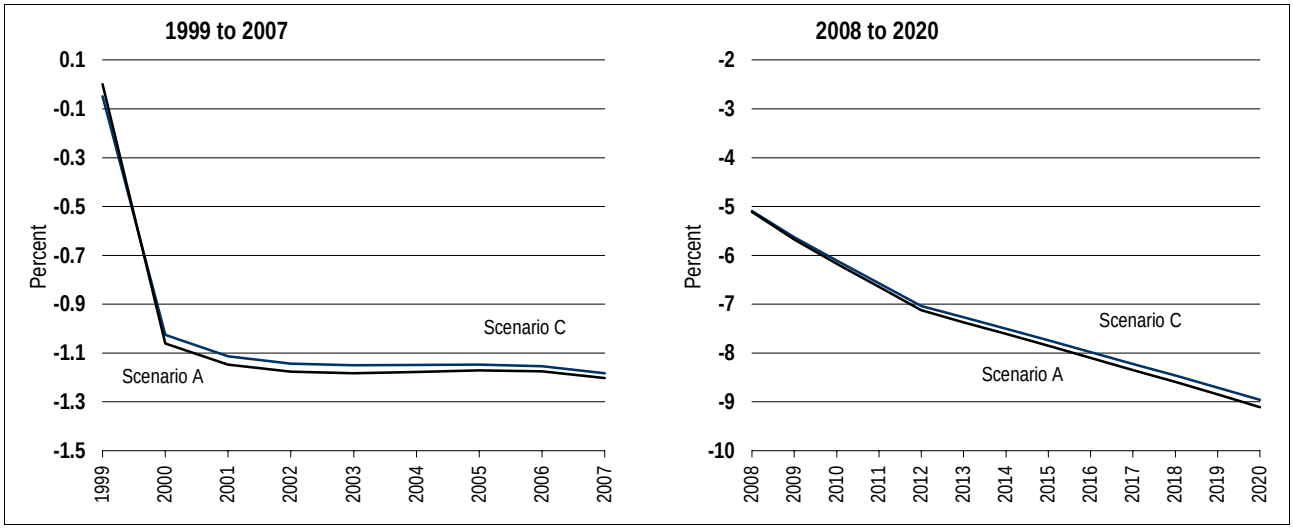
3.17 **Scenario C: summary of GDP changes relative to baseline** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	0.05	8.50	14.95	21.10	-6.11	-19.19	-29.43	-29.9	-77.66
Japan	-2.60	-5.65	-7.06	-7.80	-8.69	-12.52	-13.82	-16.9	-121.76
Australia	-0.18	-0.36	-0.47	-0.47	-3.40	-3.56	-4.10	-4.8	-26.74
New Zealand	-0.03	-0.09	-0.13	-0.13	-0.22	-0.24	-0.24	-0.2	-1.93
Canada	-1.27	-2.51	-2.54	-2.09	-6.93	-6.93	-7.19	-7.7	-56.00
Europe	-2.57	-7.08	-12.14	-16.43	-39.94	-45.85	-51.68	-57.9	-365.93
China	-0.42	-2.19	-3.06	-3.56	-5.63	-5.30	-5.45	-6.4	-48.79
non oil LDCS	-0.83	5.73	10.85	14.88	19.48	22.63	24.91	27.1	200.13
EEFSU	1.77	4.35	7.11	10.10	-7.15	-8.97	-13.34	-15.7	-35.76
World	-6.07	0.69	7.53	15.59	-58.59	-79.94	-100.35	-112.4	-534.42
Annex B	-4.82	-2.85	-0.27	4.27	-72.44	-97.27	-119.81	-133.2	-685.77

Data source: G-Cubed model simulation.

In is interesting to note that under scenario C, the reduction in emission intensity before 2008 is lower than was the case for scenario A (chart 3.18).

3.18 **Change in emission intensity relative to baseline**



Data source: G-Cubed model simulation.

The reasons for this are related to the interaction between forward looking and liquidity constrained agents alluded to above. With more forward looking firms, the activity level effect of the backward looking firms reaction to forward looking behaviour is reduced. In net, with more forward looking firms, the initial capital outflow is lower. Because the effect of the backward looking firms is reduced, and the early recession is smaller.

The net effect is that with more forward looking firms, the initial reduction in emission intensity is lower — there is less initial abatement because the early economic slow down, and there is less initial structural change in the economy.

Scenario D: early domestic tax in New Zealand only

Key results for this scenario are presented in table 3.19. In this case, the early tax only applies in New Zealand, and so New Zealand GDP is lower than scenario A up to 2008, but higher afterwards.

As in the case of scenario B, the early tax does not lower the cost of achieving the Kyoto Protocol (table 3.20) in GDP terms. It does, however, result in slightly lower cumulative costs in terms of real consumption (table A.4).

3.19 **Scenario D: Key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)[a]	0	6.64	13.28	19.91	26.55	31.55	36.55	44.55
Reduction in GDP relative to scenario A (per cent)								
USA	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Japan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Australia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
New Zealand	0.01	-0.03	-0.08	-0.12	0.01	0.06	0.07	0.00
Canada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
China	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
non oil LDCS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
EEFSU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other results for New Zealand - percentage change relative to scenario A								
Real consumption	-0.10	-0.29	-0.38	-0.31	0.42	0.48	0.41	0.00
Government spending	-0.01	-0.06	-0.10	-0.14	0.02	0.01	0.00	-0.01
Private investment	0.12	0.06	-0.03	-0.21	0.03	0.08	0.07	-0.01
Exports	0.10	0.17	0.12	-0.06	-0.44	-0.38	-0.27	0.01
Imports	0.01	-0.18	-0.36	-0.53	0.05	0.11	0.11	0.01
Nominal exchange rate NZ$/$US	0.15	0.28	0.27	0.05	-0.52	-0.48	-0.36	0.02
Long term interest rate	-0.71	-0.62	-0.37	0.13	0.59	0.52	0.37	-0.06
Aggregate employment	0.03	-0.05	-0.11	-0.16	0.09	0.13	0.12	-0.01

[a] Carbon price only applies to New Zealand before 2008

Data source: G-Cubed model simulation.

3.20 **Scenario D: change in GDP relative to scenario A** $US billion

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.0	0.01
Japan	0.00	0.00	0.01	0.01	-0.01	-0.01	-0.01	0.0	0.00
Australia	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.01
New Zealand	0.01	-0.03	-0.06	-0.10	0.01	0.05	0.07	0.0	-0.05
Canada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
Europe	0.00	0.00	0.01	0.01	0.01	-0.01	0.00	0.0	0.02
China	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
non oil LDCS	0.00	0.00	0.01	0.01	0.00	-0.01	-0.01	0.0	0.00
EEFSU	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0	0.00
World	0.02	0.00	-0.03	-0.06	0.02	0.03	0.04	0.0	-0.02
Annex B	0.02	-0.01	-0.04	-0.07	0.01	0.03	0.05	0.0	-0.02

Data source: G-Cubed model simulation.

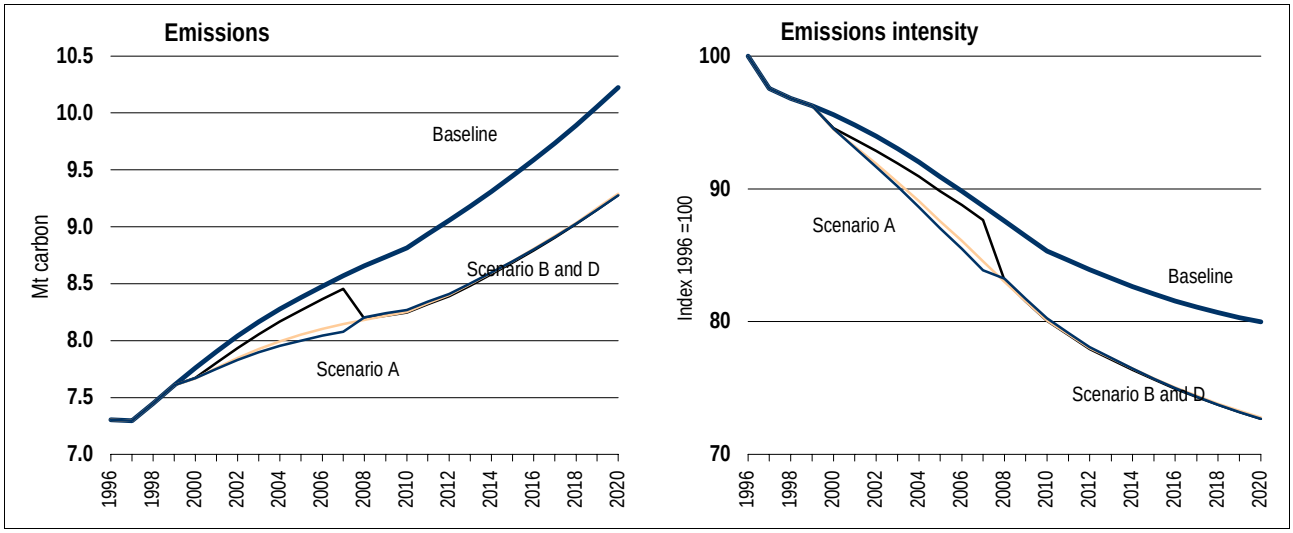
3.21 **Scenario D: change in emissions relative to scenario A** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Australia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Zealand	0.0	-0.1	-0.2	-0.3	0.0	0.0	0.0	0.0	-1.3
Canada	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Europe	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
China	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
non oil LDCS	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.1
EEFSU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
World	0.0	0.0	-0.1	-0.2	-0.1	-0.1	0.0	0.0	-1.2
Annex B	0.0	-0.1	-0.2	-0.3	0.0	0.0	0.0	0.0	-1.2

Data source: G-Cubed model simulation.

Chart 3.22 compares New Zealand's emissions and emission intensity for scenario D with the baseline, and scenarios A and B. Essentially, the path is the same as for scenario B. The early tax in New Zealand alone has the same effect in New Zealand as the early tax for all Annex B.

3.22 **Scenario D: emissions and emission intensity**



Data source: G-Cubed model simulation.

Scenario E: uniform early prices then emissions trading

Table 3.23 shows the key results for this scenario. In this case, the early tax is held at US$2.50 until 2008. As before, there are GDP losses relative to scenario A in the early years, and GDP gains after 2008. As before, the early tax does not lower the cost of achieving the Kyoto Protocol target, but it does lower cumulative costs (table 3.24). In the case of New Zealand, the present value of the GDP deviations is US$0.01 billion — the early losses offsetting the later gains. For real consumption, the net effect is zero, with the later gains just compensating for the early losses (table A.5).

3.23 **Scenario E: Key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	2.50	2.50	2.50	26.45	31.45	36.45	44.45
Reduction in GDP relative to scenario A (per cent)								
USA	0.01	-0.02	-0.03	-0.03	0.00	0.01	0.02	0.01
Japan	0.00	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00
Australia	0.01	-0.03	-0.04	-0.04	0.02	0.01	0.01	0.00
New Zealand	0.00	-0.01	-0.01	-0.01	0.00	0.01	0.01	0.00
Canada	0.03	-0.04	-0.04	-0.03	0.03	0.02	0.01	0.00
Europe	0.01	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.00
China	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
non oil LDCS	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00
EEFSU	0.03	-0.05	-0.06	-0.07	0.03	0.03	0.03	0.01
Other results for New Zealand - percentage change relative to scenario A								
Real consumption	-0.04	-0.04	-0.03	0.00	0.02	0.03	0.03	0.00
Government spending	0.00	-0.02	-0.01	-0.01	0.00	0.00	0.00	0.00
Private investment	0.02	0.00	0.00	-0.01	-0.02	-0.01	0.00	0.00
Exports	0.05	0.00	-0.03	-0.05	-0.01	-0.02	-0.01	0.00
Imports	0.00	-0.05	-0.05	-0.05	-0.01	0.00	0.00	0.00
Nominal exchange rate NZ$/$US	0.07	0.04	0.03	0.02	0.05	0.05	0.04	0.04
Long term interest rate	-0.12	-0.09	-0.05	0.01	0.05	0.05	0.04	0.00
Aggregate employment	0.01	-0.02	-0.01	-0.01	0.01	0.02	0.01	0.00

Data source: G-Cubed model simulation.

3.24 **Scenario E: changes in GDP relative to scenario A** $US billion

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	0.94	-2.16	-2.59	-2.79	0.35	1.37	1.83	1.00	-3.77
Japan	-0.02	-0.38	-0.38	-0.39	-0.33	-0.02	0.04	0.07	-1.66
Australia	0.05	-0.17	-0.19	-0.19	0.10	0.07	0.07	0.02	-0.61
New Zealand	0.00	-0.01	-0.01	-0.01	0.00	0.01	0.01	0.00	-0.01
Canada	0.20	-0.28	-0.28	-0.28	0.24	0.17	0.12	0.01	-0.72
Europe	0.81	-0.94	-1.18	-1.27	0.71	0.68	0.65	0.15	-2.69
China	0.12	0.10	0.02	-0.05	0.08	-0.01	-0.05	-0.06	-0.42
non oil LDCS	-0.03	0.19	0.29	0.36	0.23	0.15	0.08	0.05	1.94
EEFSU	0.61	-0.93	-1.20	-1.34	0.54	0.54	0.67	0.37	-2.56
World	2.68	-4.58	-5.51	-5.95	1.91	2.95	3.41	1.61	-10.50
Annex B	2.58	-4.87	-5.81	-6.26	1.60	2.81	3.38	1.62	-12.02

Data source: G-Cubed model simulation.

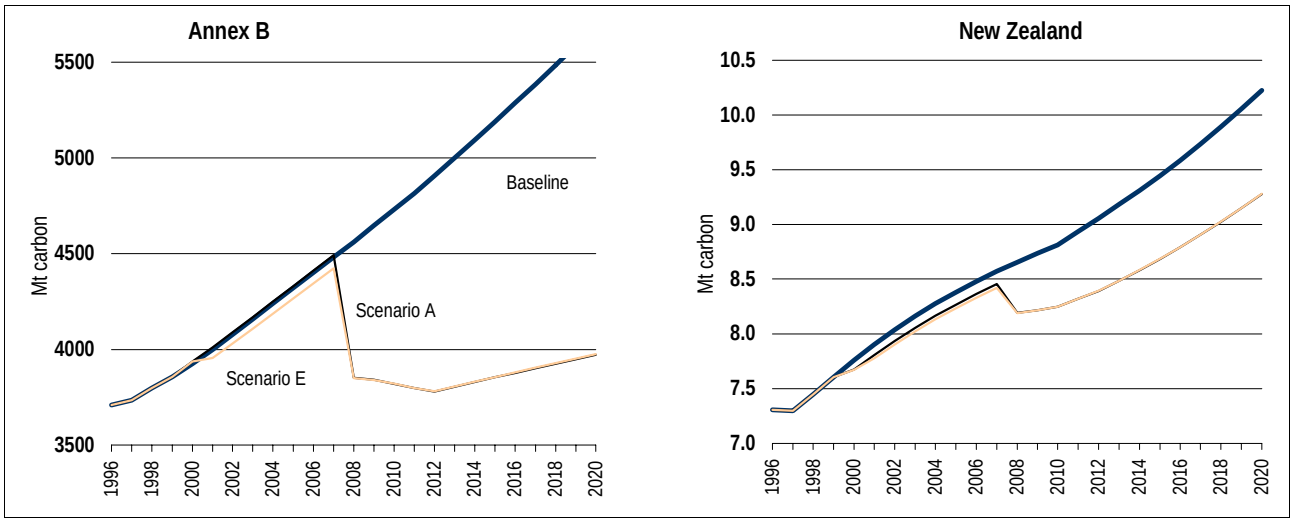
3.25 **Scenario E: changes in emissions relative to scenario A** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	0.3	-20.3	-22.1	-23.6	-0.9	0.0	0.5	1.5	-144.7
Japan	0.0	-1.0	-1.1	-1.2	-0.2	-0.1	-0.1	0.0	-8.4
Australia	0.0	-1.0	-1.0	-1.1	0.0	0.0	0.0	0.1	-6.6
New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.2
Canada	0.0	-1.8	-1.9	-2.1	-0.1	-0.1	0.0	0.1	-13.6
Europe	0.1	-4.5	-4.9	-5.3	-0.4	-0.3	-0.1	0.1	-35.7
China	0.1	0.1	0.0	-0.1	-0.1	-0.2	-0.2	-0.1	-2.5
non oil LDCS	0.0	1.7	1.7	1.6	-0.5	-0.3	-0.2	0.1	9.9
EEFSU	0.4	-29.9	-32.0	-34.0	0.3	0.6	1.1	1.8	-208.5
World	0.9	-56.6	-61.5	-65.9	-1.9	-0.3	1.0	3.5	-410.4
Annex B	0.8	-58.5	-63.2	-67.4	-1.2	0.2	1.4	3.5	-417.8

Data source: G-Cubed model simulation

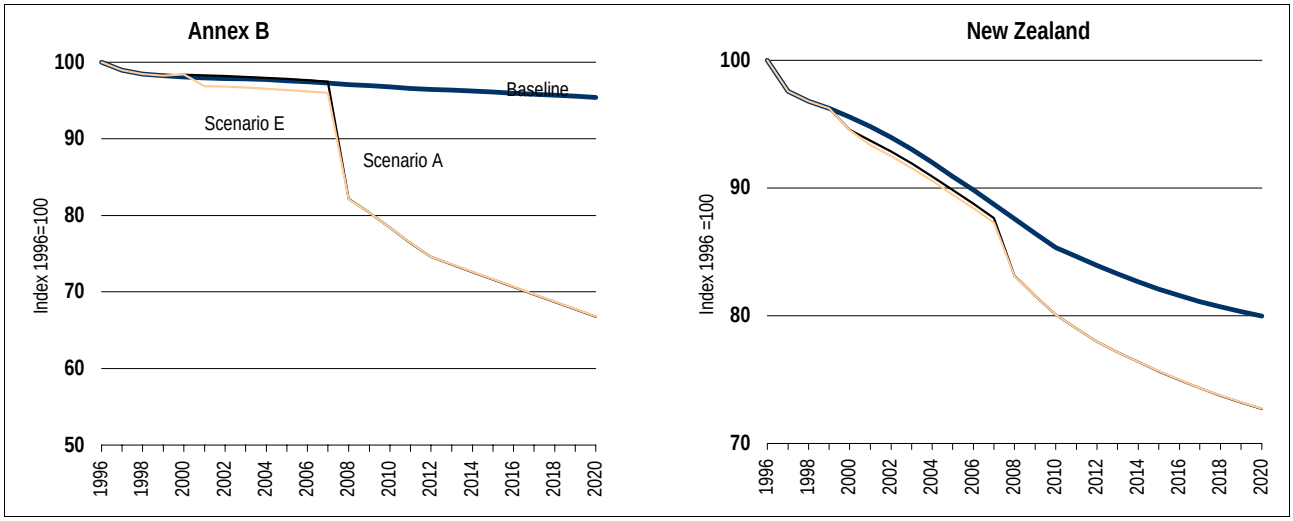
Chart 3.26 shows that with the uniform tax, box Annex B and New Zealand's emissions are below baseline before 2008. This time the reduction is not as great as for scenario B, and as before emissions return to the same path as scenario A after 2008. Chart 3.27 shows a similar story for emissions intensity.

3.26 **Scenario E: emissions**



Data source: G-Cubed model simulation.

3.27 **Scenario E: emissions intensity**



Data source: G-Cubed model simulation.

Scenario F: 10 per cent easier target for New Zealand

This simulation involves both an early tax and an effective increase in New Zealand's initial allocation under international emissions trading.

Key results for this scenario are presented in table 3.14. The tax profile is the same as previously. Comparing table 3.28 with table 3.10 shows a similar pattern of early loss in GDP (relative to scenario A) as was the case with scenario B. However, New Zealand's higher initial permit allocation means that there is a greater gain from 2008 on. A similar pattern follows for real consumption — although in this case there is also a smaller loss before 2008 (table A.6).

3.28 **Scenario F: Key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	6.48	12.95	19.43	25.9	30.9	35.9	43.9
Reduction in GDP relative to scenario A (per cent)								
USA	0.02	-0.05	-0.13	-0.22	-0.02	0.04	0.07	0.05
Japan	0.00	-0.01	-0.03	-0.05	-0.05	0.00	0.00	0.01
Australia	0.02	-0.10	-0.20	-0.31	0.12	0.06	0.07	0.02
New Zealand	0.01	-0.02	-0.04	-0.07	0.02	0.04	0.05	0.01
Canada	0.05	-0.11	-0.22	-0.34	0.17	0.12	0.09	0.01
Europe	0.01	-0.02	-0.06	-0.10	0.03	0.02	0.03	0.01
China	0.02	0.00	-0.01	-0.02	0.04	0.00	-0.01	-0.01
non oil LDCS	0.00	0.01	0.03	0.04	0.03	0.02	0.01	0.00
EEFSU	0.06	-0.14	-0.34	-0.58	0.12	0.09	0.14	0.09
Other results for New Zealand - percentage change relative to scenario A								
Real consumption	-0.06	-0.11	-0.11	-0.01	0.14	0.24	0.24	0.09
Government spending	-0.01	-0.04	-0.08	-0.11	0.00	0.00	-0.01	-0.01
Private investment	0.09	0.12	0.10	-0.01	-0.17	-0.01	0.02	0.03
Exports	0.07	-0.02	-0.15	-0.37	-0.10	-0.18	-0.13	-0.04
Imports	-0.01	-0.12	-0.23	-0.36	-0.09	-0.01	0.03	0.01
Nominal exchange rate NZ$/$US	0.23	0.16	0.05	-0.09	0.22	0.17	0.15	0.13
Long term interest rate	-0.52	-0.53	-0.41	-0.09	0.27	0.29	0.24	0.01
Aggregate employment	0.03	-0.03	-0.07	-0.11	0.06	0.08	0.08	0.01

Data source: G-Cubed model simulations.

Table 3.29 shows that the cumulative change in GDP for New Zealand (relative to scenario A) is now positive. This is a result of the greater initial allocation in permits.

3.29 **Scenario F: changes in GDP relative to scenario A** US$billion

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	1.76	-4.53	-12.61	-23.05	-2.29	4.94	8.90	6.43	-27.56
Japan	0.00	-0.61	-1.55	-2.58	-2.99	-0.26	0.16	0.42	-8.12
Australia	0.10	-0.47	-1.03	-1.67	0.64	0.35	0.40	0.12	-3.30
New Zealand	0.01	-0.01	-0.04	-0.06	0.02	0.04	0.04	0.02	0.02
Canada	0.38	-0.80	-1.67	-2.78	1.45	1.07	0.81	0.09	-4.42
Europe	1.26	-2.70	-6.82	-11.68	3.41	3.08	3.36	1.13	-21.52
China	0.18	0.02	-0.11	-0.44	0.92	0.08	-0.23	-0.29	-3.06
non oil LDCS	-0.06	0.56	1.35	2.29	1.53	1.07	0.61	0.11	10.68
EEFSU	1.08	-2.56	-6.51	-11.62	2.52	1.89	3.08	2.26	-19.48
World	4.71	-11.09	-29.00	-51.60	5.21	12.26	17.14	10.30	-76.76
Annex B	4.59	-11.67	-30.24	-53.44	2.76	11.11	16.76	10.47	-84.38

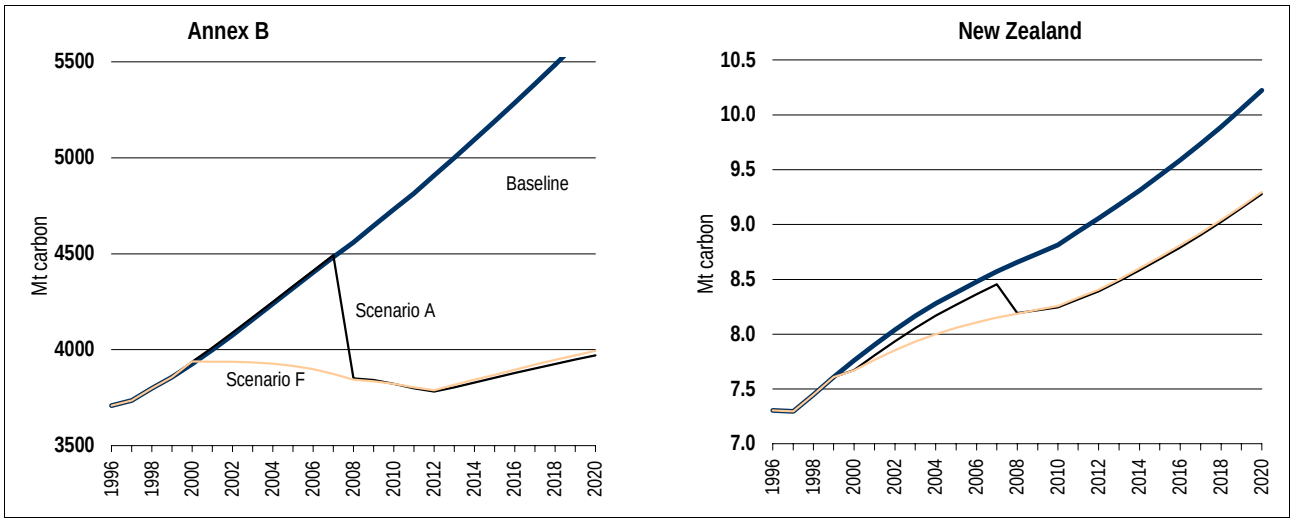
Data source: G-Cubed model simulations

3.30 **Scenario F: change in emissions relative to scenario A** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	1.0	-51.8	-111.8	-179.1	-6.3	-0.8	3.1	9.3	-754.7
Japan	0.0	-2.6	-5.6	-9.1	-1.2	-0.6	-0.3	0.2	-43.5
Australia	0.0	-2.5	-5.3	-8.3	0.3	0.2	0.3	0.3	-34.4
New Zealand	0.0	-0.1	-0.2	-0.3	0.0	0.0	0.0	0.0	-1.0
Canada	-0.1	-4.7	-9.9	-15.5	-0.4	-0.3	-0.1	0.4	-70.6
Europe	-0.1	-11.7	-24.9	-39.8	-2.5	-1.5	-0.7	0.9	-186.3
China	0.0	0.0	-0.1	-0.6	-0.2	-0.8	-0.9	-0.5	-13.9
non oil LDCS	0.4	5.0	9.4	13.8	-3.2	-2.2	-1.6	0.2	51.2
EEFSU	0.6	-77.9	-164.9	-261.6	2.6	3.7	6.6	11.7	-1,089.6
World	1.8	-146.2	-313.2	-500.3	-11.0	-2.2	6.3	22.7	-2,142.8
Annex B	1.4	-151.2	-322.5	-513.6	-7.5	0.8	8.8	22.9	-2,180.1

Data source: G-Cubed model simulations

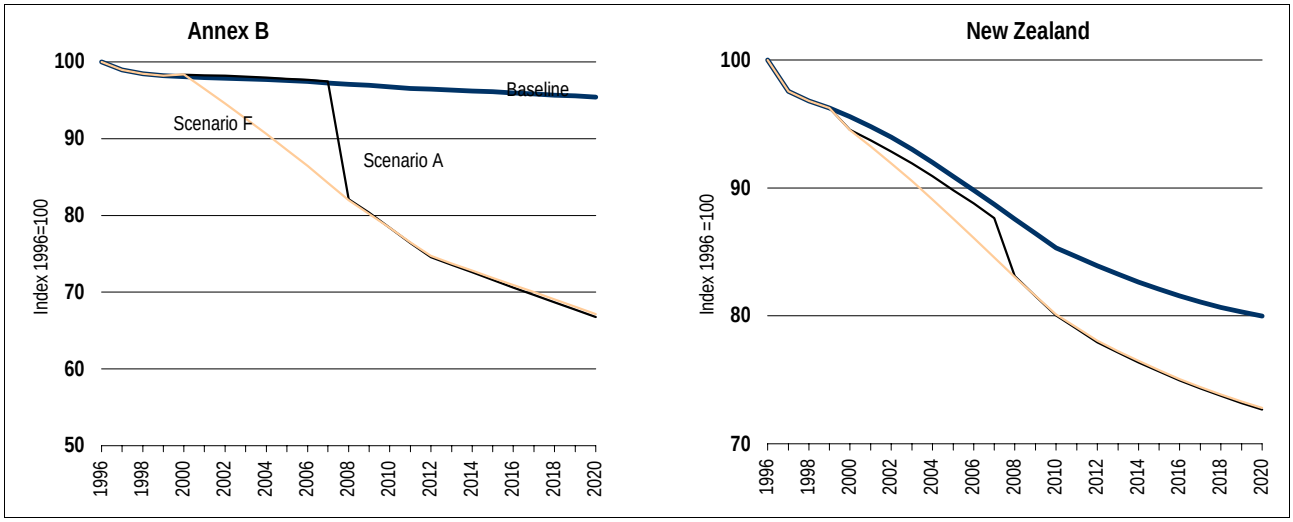
3.31 **Scenario F: emissions**



Data source: G-Cubed model simulation.

The emissions and emissions intensity path for scenario F is similar to that for scenario B.

3.32 **Scenario F: emissions intensity**



Data source: G-Cubed model simulation.

4 Other scenarios

Scenario G: EEFSU not trading

Under this scenario, emissions trading takes place as in scenario A, except that the EEFSU is excluded from the trading scheme. The key results is that the permit price is higher than under scenario A, starting at US$47 per tonne of carbon in 2008 and increasing to US$87 by 2020 (table 4.1). The subsequent GDP effects are greater for all countries, with GDP for New Zealand declining by up to 0.52 per cent (in 2010) and consumption declining by up to 2 per cent (2008).

4.1 **Scenario G: summary of key results**

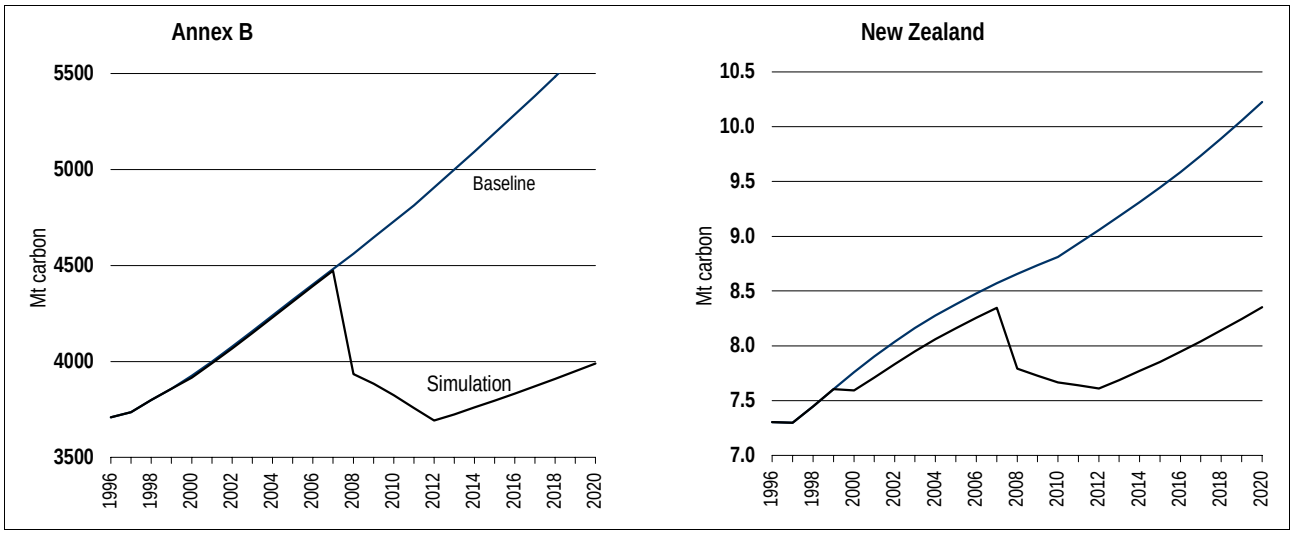
	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	0	0	0	47	63	79	87
Reduction in GDP relative to baseline (per cent)								
USA	0.01	0.26	0.43	0.57	0.15	-0.12	-0.37	-0.23
Japan	-0.10	-0.22	-0.26	-0.28	-0.31	-0.42	-0.45	-0.43
Australia	-0.07	-0.01	0.00	0.04	-0.88	-1.02	-1.27	-1.12
New Zealand	-0.09	-0.24	-0.31	-0.31	-0.47	-0.52	-0.53	-0.31
Canada	-0.32	-0.57	-0.54	-0.41	-1.38	-1.45	-1.57	-1.21
Europe	-0.05	-0.16	-0.26	-0.34	-0.68	-0.81	-0.93	-0.87
China	-0.08	-0.38	-0.46	-0.48	-0.55	-0.51	-0.48	-0.37
non oil LDCS	-0.05	0.38	0.67	0.86	1.01	1.08	1.10	0.92
EEFSU	-0.04	-0.05	-0.07	-0.09	-0.07	-0.09	-0.11	-0.24
Other results for New Zealand percentage change relative to baseline								
Real consumption	-1.58	-2.02	-2.08	-2.05	-2.14	-1.95	-1.54	-0.07
Government spending	-0.38	-0.34	-0.30	-0.28	-0.52	-0.60	-0.69	-0.80
Private investment	-1.96	-1.57	-1.27	-0.90	-0.55	-0.72	-0.82	-0.96
Exports	2.51	2.33	2.02	1.78	0.86	0.33	-0.38	-1.43
Imports	-2.16	-2.48	-2.57	-2.54	-3.20	-3.53	-3.80	-3.75
Nominal exchange rate NZ$/$US	12.75	13.46	13.39	13.07	11.88	11.34	10.91	11.70
Long term interest rate	-0.15	-0.67	-1.10	-1.66	-2.17	-1.98	-1.49	-0.13

Data source: G-Cubed model simulation

Chart 4.2 illustrates that while total annex B abatement is the same for this scenario as for scenario A, New Zealand undertakes more abatement than previously. This is further illustrated in table 4.3. Cumulative New Zealand abatement (1999 to 2020) is twice what it was in scenario A (20.8Mt versus

10.2Mt). Further, early abatement is also twice what it is in scenario A. Because the ultimate permit price is higher, forward looking agents undertake more early action in order to minimise the total cost of achieving the target.

4.2 **Scenario G: carbon emissions** Annex B total and New Zealand



Data source: G-Cubed model simulation

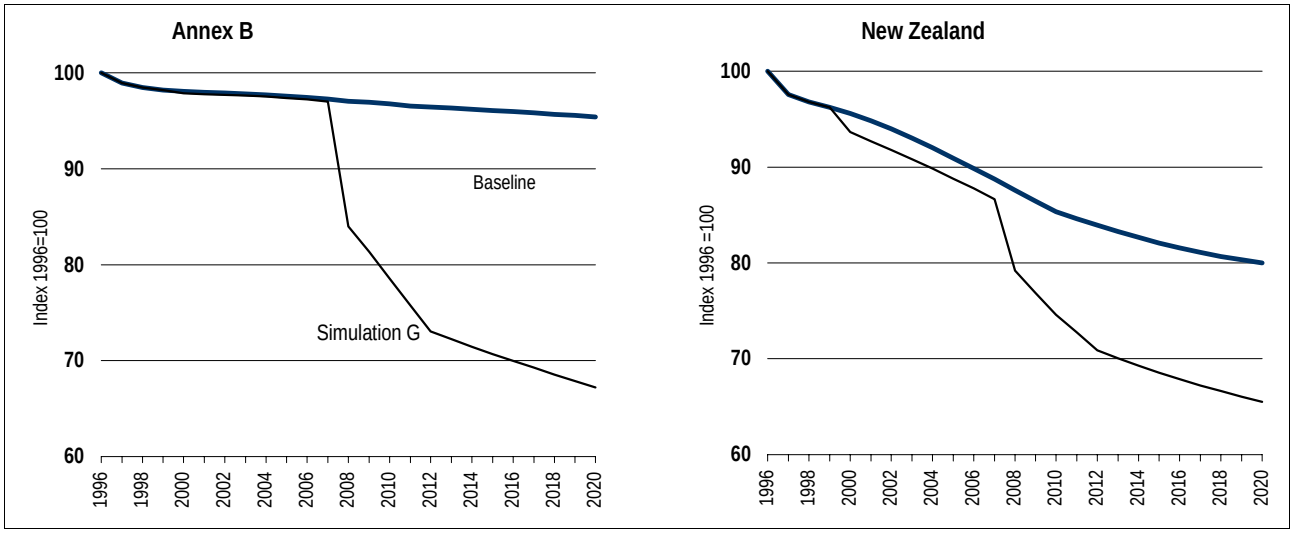
4.3 **Scenario G: summary of emissions changes relative to baseline** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	25.5	33.5	38.1	41.1	-397.9	-598.0	-816.0	-1,147.6	-10,736.5
Japan	-6.5	-7.7	-8.3	-8.6	-31.3	-42.7	-54.8	-76.8	-814.5
Australia	-0.5	-0.5	-0.5	-0.4	-21.7	-30.3	-39.9	-54.1	-536.8
New Zealand	-0.2	-0.2	-0.2	-0.2	-0.9	-1.1	-1.4	-1.9	-20.8
Canada	-4.0	-5.3	-5.6	-5.8	-44.0	-60.6	-78.9	-110.1	-1,115.0
Europe	-17.1	-22.2	-26.0	-29.1	-133.0	-179.7	-230.9	-313.9	-3,313.6
China	-9.0	-13.2	-13.7	-14.0	-14.2	-14.5	-15.5	-21.5	-328.5
non oil LDCS	53.1	69.2	78.1	83.7	118.6	129.8	141.0	149.2	2,391.6
EEFSU	-6.7	-6.6	-6.8	-7.1	3.3	5.1	7.3	1.2	0.9
World	34.7	47.1	55.1	59.5	-521.1	-792.0	-1,089.1	-1,575.5	-14,473.4
Annex B	-9.4	-8.8	-9.2	-10.2	-625.5	-907.3	-1,214.7	-1,703.2	-16,536.4

Data source: G-Cubed model simulation

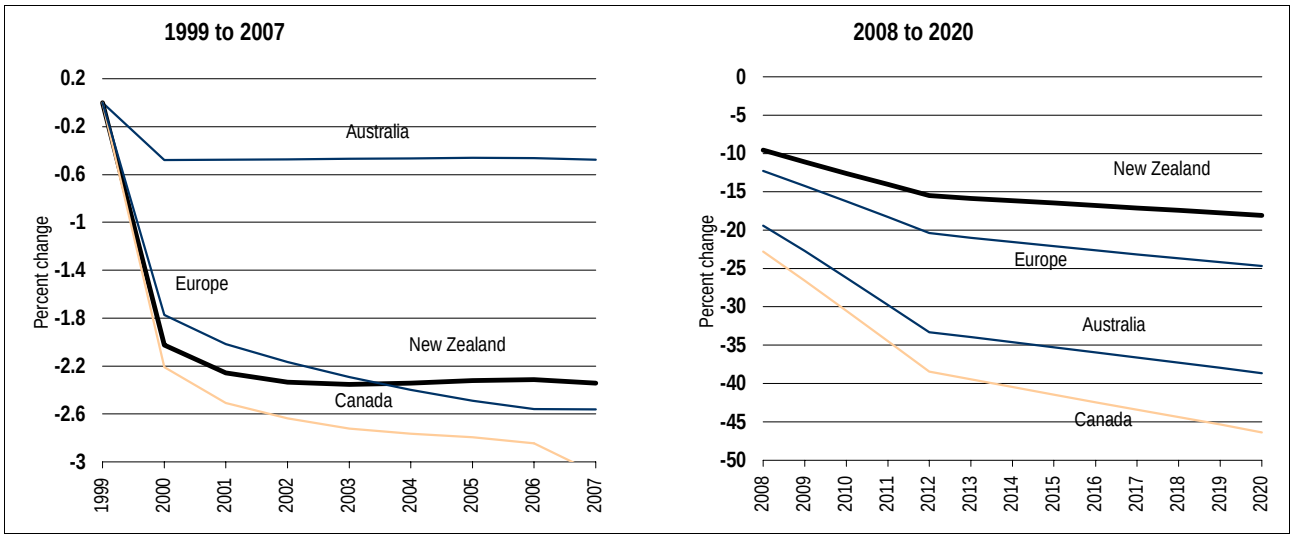
Reflecting this, New Zealand's emissions intensity declines more rapidly than previously (chart 4.4). This is also the case for other regions (chart 4.5).

4.4 **Scenario G: emissions intensity** Annex B total and New Zealand



Data source: G-Cubed model simulation

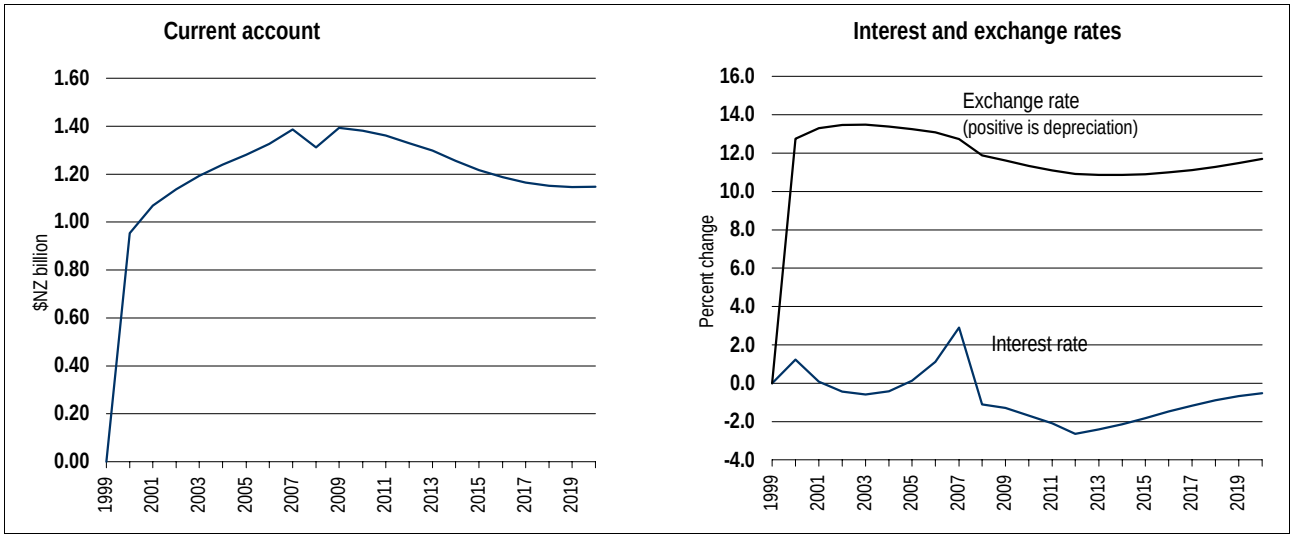
4.5 **Scenario G: change in emission intensity relative to baseline**



Data source: G-Cubed model simulation

Chart 4.6 illustrates that in this scenario with higher permit prices, the capital outflow from New Zealand (measured by the current account surplus) is greater, as is the subsequent change in interest and exchange rates.

4.6 **Scenario G: current account, interest rates and exchange rates**



Data source: G-Cubed model simulation

4.7 **Scenario G: summary of GDP changes relative to baseline** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	0.64	24.87	43.50	60.09	16.26	-14.01	-43.95	-31.8	39.93
Japan	-5.04	-11.51	-14.35	-15.72	-18.50	-25.71	-29.23	-33.2	-248.65
Australia	-0.31	-0.07	0.02	0.20	-4.93	-5.97	-7.75	-8.2	-42.43
New Zealand	-0.06	-0.19	-0.25	-0.26	-0.42	-0.48	-0.51	-0.4	-3.90
Canada	-2.28	-4.26	-4.25	-3.33	-11.66	-12.81	-14.43	-13.1	-100.27
Europe	-5.04	-17.17	-29.13	-39.73	-82.60	-101.97	-120.84	-129.2	-839.55
China	-0.99	-5.24	-7.28	-8.85	-11.36	-11.65	-12.16	-13.6	-112.51
non oil LDCS	-1.99	17.42	32.52	44.41	55.23	62.87	68.39	72.6	561.78
EEFSU	-0.76	-0.90	-1.40	-1.89	-1.34	-2.00	-2.43	-6.4	-27.72
World	-15.84	2.95	19.40	34.93	-59.33	-111.72	-162.93	-163.1	-773.32
Annex B	-12.85	-9.24	-5.84	-0.63	-103.20	-162.95	-219.15	-222.1	-1222.59

Data source: G-Cubed model simulation

Scenario H: early taxes with EEFSU excluded from trading

Table 4.8 summarises the key results from this scenario. As for scenario B, the early tax is phased in using equal increments. The early tax results in GDP losses before 2008, but for New Zealand, GDP gains after 2008, relative to scenario G.

4.8 **Scenario H: key results**

	2000	2002	2004	2006	2008	2010	2012	2020
Permit price ($US/t carbon)	0	11.35	22.70	34.05	45.4	61.4	77.4	85.4
Reduction in GDP relative to scenario A (per cent)								
USA	0.03	-0.09	-0.23	-0.40	-0.05	0.07	0.13	0.08
Japan	0.00	-0.02	-0.05	-0.09	-0.08	0.00	0.01	0.01
Australia	0.04	-0.18	-0.37	-0.56	0.20	0.10	0.12	0.03
New Zealand	0.02	-0.05	-0.10	-0.15	0.02	0.06	0.07	0.02
Canada	0.09	-0.19	-0.38	-0.61	0.31	0.23	0.16	0.02
Europe	0.02	-0.05	-0.11	-0.18	0.04	0.05	0.05	0.03
China	0.01	0.00	0.00	-0.01	0.04	0.00	-0.01	-0.01
non oil LDCS	0.00	0.01	0.03	0.05	0.03	0.02	0.00	-0.01
EEFSU	0.00	0.01	0.02	0.03	-0.02	0.00	0.00	0.00
Other results for New Zealand - percentage change relative to scenario A								
Real consumption	-0.23	-0.36	-0.39	-0.21	0.21	0.37	0.35	0.04
Government spending	-0.01	-0.08	-0.14	-0.19	0.00	0.00	0.00	0.00
Private investment	0.09	0.14	0.09	-0.11	-0.31	-0.06	0.00	0.02
Exports	0.28	0.14	-0.08	-0.47	-0.16	-0.27	-0.17	0.03
Imports	-0.01	-0.22	-0.45	-0.67	-0.13	0.02	0.08	0.03
Nominal exchange rate NZ$/$US	0.44	0.31	0.11	-0.15	0.31	0.23	0.22	0.20
Long term interest rate	-1.02	-1.02	-0.77	-0.13	0.53	0.56	0.46	0.01

Data source: G-Cubed model simulation

As before, the early tax results in additional early abatement (table 4.10) and a net loss in GDP (table 4.9). In this case there is also a small net loss in real consumption (table A.8).

4.9 **Scenario H: change in GDP relative to scenario G** $US billion

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Present value 1999 to 2020*
USA	3.06	-8.47	-23.13	-41.91	-4.99	8.08	15.22	10.85	-56.08
Japan	0.13	-1.08	-2.89	-4.88	-4.53	0.00	0.74	0.99	-12.60
Australia	0.18	-0.86	-1.87	-3.03	1.11	0.61	0.71	0.21	-6.12
New Zealand	0.01	-0.04	-0.08	-0.13	0.02	0.06	0.07	0.02	-0.10
Canada	0.67	-1.41	-2.96	-4.92	2.61	1.97	1.49	0.17	-7.54
Europe	1.91	-5.00	-12.40	-21.08	4.88	5.97	6.93	3.70	-32.73
China	0.14	0.01	-0.06	-0.27	0.85	0.09	-0.23	-0.41	-2.71
non oil LDCS	-0.06	0.58	1.52	2.70	1.63	0.98	0.27	-0.50	9.68
EEFSU	-0.04	0.12	0.32	0.52	-0.43	-0.03	-0.08	-0.01	1.36
World	6.01	-16.15	-41.56	-72.99	1.15	17.72	25.13	15.02	-106.84
Annex B	5.92	-16.73	-43.01	-75.42	-1.33	16.65	25.09	15.93	-113.81

Data source: G-Cubed model simulation

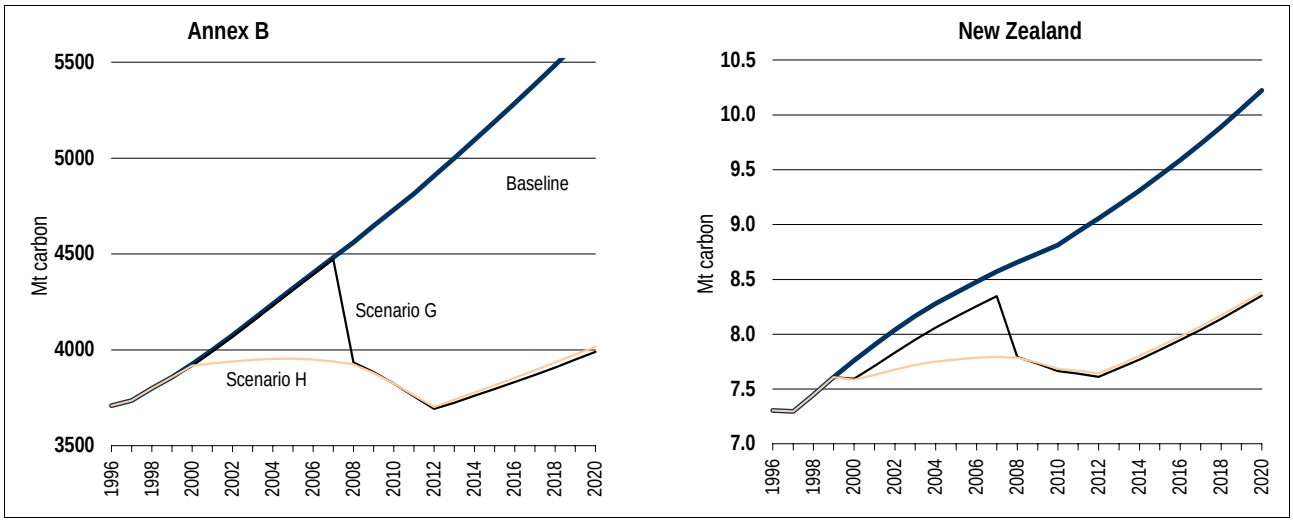
4.10 **Scenario H: change in emission relative to scenario G** Mt carbon

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	1.3	-91.9	-197.7	-316.2	-6.9	3.0	10.0	21.9	-1,272.2
Japan	0.1	-4.7	-10.3	-16.6	-1.3	-0.4	0.1	1.0	-71.6
Australia	0.0	-4.4	-9.3	-14.7	0.7	0.6	0.7	0.9	-57.6
New Zealand	0.0	-0.2	-0.3	-0.5	0.0	0.0	0.0	0.0	-1.9
Canada	-0.1	-8.3	-17.3	-27.3	-0.2	0.0	0.3	1.3	-117.7
Europe	0.1	-21.3	-45.3	-72.2	-0.6	0.6	1.7	4.0	-300.5
China	0.0	0.1	0.1	-0.3	-0.9	-1.3	-1.3	-0.8	-17.7
non oil LDCS	0.0	6.6	13.1	19.9	-4.8	-3.8	-3.2	-0.9	59.1
EEFSU	-0.3	1.8	3.7	5.5	-3.7	-2.4	-1.9	-0.5	5.6
World	1.2	-122.2	-263.3	-422.5	-17.7	-3.7	6.3	26.9	-1,774.7
Annex B	1.1	-129.0	-276.5	-442.1	-12.0	1.4	10.9	28.6	-1,816.0

Data source: G-Cubed model simulation

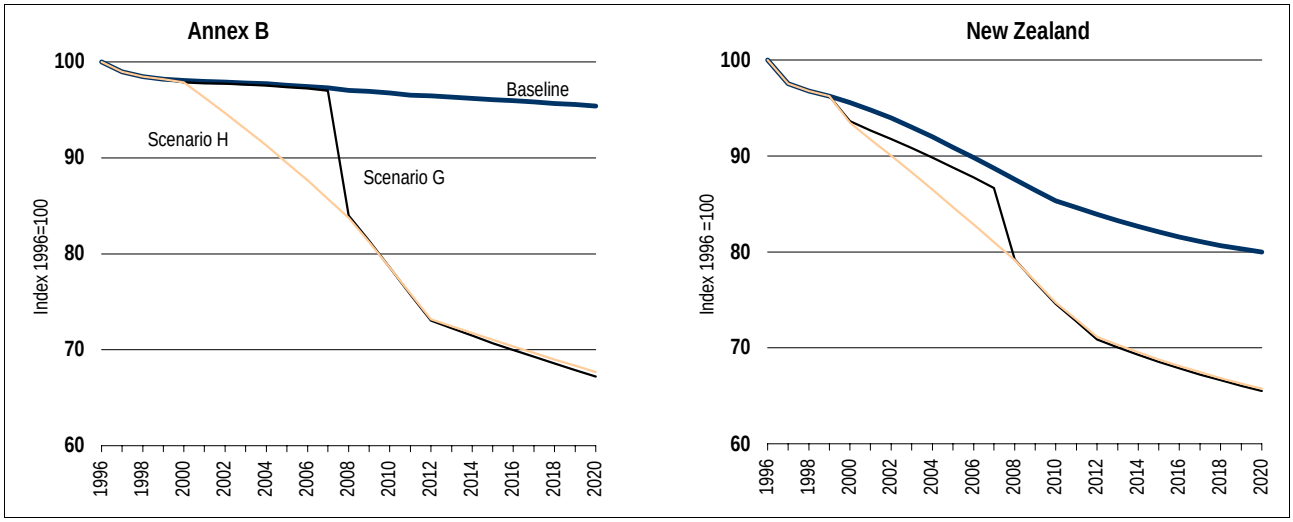
Comparing emissions and emission intensity for scenarios G and H (charts 4.11 and 4.12) shows the same pattern of results as previously. The early tax leads to lower emissions (and emissions intensity) before 2008, but after 2008, both return to approximately the same path as the case without the early tax.

4.11 **Emissions: scenarios G and H** Annex B and New Zealand



Data source: G-Cubed model simulation

4.12 **Emission intensity: scenario G and H**



Data source: G-Cubed model simulation

5 Conclusions

Shares in international abatement

The treatment of EEFSU in the simulations is likely to have a significant impact on the results. Here, EEFSU is treated as region abating in the same way as all other Annex B regions. It ends up doing a significant proportion of abatement under the Kyoto Protocol because of very low marginal abatement costs. EEFSU is the most uncertain region however, and an alternative treatment may be appropriate.

Some early action takes place 'endogenously'

Early abatement takes place in the simulations without any explicit early taxes. This is because of the forward-looking behaviour of agents who see the future target as fully credible. The early abatement takes place through a variety of model mechanisms, all related to the forward looking behaviour of some agents in the model.

Early taxes result in more early abatement…

Early taxes result in more abatement before the commitment period than is the case without the early taxes. The greatest reduction in emissions is for those countries with relatively low marginal costs of abatement — especially EEFSU.

…but do not lower the costs of the Kyoto target

Relative to emissions trading without early tax, the early tax lowers GDP before the commitment period, but raises it later. However, this results in a net loss in GDP over the period — the later gains to not outweigh the early losses (using a discount rate of 5 per cent).

That is, the early taxes as implemented in the simulations here do not lower the total costs of achieving the Kyoto Protocol target. The early taxes do not provide the forward-looking agents with any additional information about outcomes in the commitment period. Thus, these agents return to essentially the same path of abatement in the commitment period as they do in the case without early taxes.

But early taxes do lower cumulative costs

Early taxes do lower the cumulative costs of cumulative emissions reductions. That is, the total GDP loss for a given level of cumulative abatement (measured from 1999 to 2020, for example, rather than just in the commitment period) is lower when abatement is phased rather than when it is introduced suddenly.

Unfortunately, the Kyoto Protocol targets the level of emissions in a particular period rather than cumulative abatement over a period. This is despite scientific evidence that concentration of emissions, rather than the level, counts for global warming.

The results presented here suggest that early action can lower costs of reducing the concentration of emissions (cumulative emissions) over any given period, but is unlikely to lower the costs of achieving a particular level of emissions in a particular period.

Policy implications

An implication of these results is that in a world in which forward looking agents are able to adjust to an expected future permit trading scheme, then an early tax does not lower the cost of this adjustment. Essentially, the early tax does not provide any additional information to the agents in the economy.

However, there are two key differences between the simulated world and the real world. First, agents do not necessarily expect emission trading under the Kyoto Protocol to come into force — indeed, some may expect the exact opposite. Second, even those firms that do expect the Kyoto Protocol to come into force do not know with certainty the future price of emissions.

For the government to play a role in early action, it needs to make a contribution to either the formation of expectations about the Kyoto Protocol, or to information about future prices. While an early tax may be able to play such a role, some caution is needed. First, it is unlikely that the government has better information about future permit prices that agents and firms if the economy. Second, it may be perfectly appropriate for firms to take different views about the likelihood of the Kyoto Protocol coming into force.

A Results for real consumption

A.1 **Scenario A: change in real consumption relative to baseline** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	24.16	43.55	55.95	65.97	45.06	41.96	39.81	63.41	586.97
Japan	-10.86	-18.00	-22.02	-24.29	-19.58	-23.71	-24.92	-32.49	-278.51
Australia	-1.51	-1.76	-1.84	-1.84	-4.51	-3.82	-3.70	-2.96	-31.93
New Zealand	-0.42	-0.55	-0.59	-0.62	-0.62	-0.59	-0.49	-0.18	-6.01
Canada	-5.85	-8.44	-9.17	-9.11	-17.56	-15.90	-14.98	-13.69	-140.58
Europe	-33.65	-54.99	-68.49	-77.09	-99.73	-100.83	-104.08	-113.54	-1001.60
China	-4.94	-9.81	-12.63	-13.93	-16.68	-15.84	-15.60	-16.78	-161.85
non oil LDCS	23.74	40.49	50.13	56.22	69.46	72.77	75.45	76.79	721.44
EEFSU	19.93	25.19	28.85	32.02	4.36	10.27	11.11	29.12	260.62
World	10.60	15.69	20.18	27.34	-39.80	-35.70	-37.41	-10.29	-51.45
Annex B	-8.21	-15.00	-17.31	-14.96	-92.58	-92.63	-97.25	-70.31	-611.04

Data source: G-Cubed model simulation

A.2 **Scenario B: change in real consumption relative to scenario A** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	3.30	-1.24	-6.54	-13.59	7.74	10.88	12.78	9.36	34.63
Japan	0.12	0.85	1.16	1.33	-4.40	-1.45	-1.11	-0.54	-1.45
Australia	0.04	-0.47	-0.83	-1.10	1.41	0.71	0.58	0.09	-0.69
New Zealand	-0.06	-0.09	-0.09	-0.04	0.04	0.10	0.10	0.02	0.01
Canada	-0.03	-2.01	-3.17	-4.07	3.99	2.35	1.34	-0.07	-6.96
Europe	0.58	-3.05	-5.44	-8.11	6.22	1.48	-0.46	-4.16	-35.50
China	-0.03	-0.36	-0.55	-0.87	1.00	-0.32	-0.94	-0.91	-9.28
non oil LDCS	0.63	3.25	5.55	7.77	0.31	0.56	0.37	1.68	33.48
EEFSU	1.07	-4.26	-8.61	-13.59	11.42	6.39	5.79	2.18	-11.38
World	5.64	-7.37	-18.52	-32.27	27.73	20.72	18.45	7.64	2.86
Annex B	5.04	-10.26	-23.52	-39.17	26.41	20.48	19.02	6.87	-21.34

Data source: G-Cubed model simulation

A.3 **Scenario C: change in real consumption relative to baseline** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	24.16	43.55	55.94	65.96	45.06	41.95	39.81	63.41	586.92
Japan	-10.86	-18.01	-22.03	-24.30	-19.59	-23.72	-24.93	-32.49	-278.57
Australia	-1.51	-1.76	-1.84	-1.84	-4.51	-3.82	-3.70	-2.95	-31.93
New Zealand	-0.40	-0.53	-0.57	-0.59	-0.60	-0.56	-0.47	-0.18	-5.79
Canada	-5.86	-8.44	-9.17	-9.11	-17.56	-15.90	-14.99	-13.68	-140.59
Europe	-33.66	-55.00	-68.50	-77.10	-99.74	-100.84	-104.09	-113.54	-1001.66
China	-4.94	-9.81	-12.63	-13.93	-16.68	-15.84	-15.60	-16.77	-161.85
non oil LDCS	23.74	40.49	50.12	56.22	69.46	72.76	75.44	76.80	721.39
EEFSU	19.93	25.19	28.85	32.02	4.36	10.26	11.11	29.12	260.61
World	10.60	15.69	20.18	27.34	-39.80	-35.70	-37.41	-10.29	-51.46
Annex B	-8.21	-14.99	-17.31	-14.95	-92.57	-92.63	-97.25	-70.31	-611.00

Data source: G-Cubed model simulation

A.4 **Scenario D: change in real consumption relative to scenario A** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	0.01	0.02	0.02	0.02	-0.01	-0.02	-0.02	-0.01	0.00
Japan	0.01	0.02	0.03	0.02	-0.04	-0.04	-0.03	0.01	0.00
Australia	0.00	0.01	0.02	0.01	-0.02	-0.03	-0.03	0.00	-0.03
New Zealand	-0.04	-0.13	-0.18	-0.15	0.21	0.25	0.22	0.00	0.17
Canada	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Europe	0.01	0.02	0.02	0.01	0.00	-0.02	-0.02	-0.01	-0.03
China	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	-0.01
non oil LDCS	0.00	0.02	0.03	0.04	-0.04	-0.04	-0.04	-0.01	-0.03
EEFSU	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
World	-0.01	-0.04	-0.05	-0.04	0.10	0.09	0.07	-0.01	0.08
Annex B	-0.01	-0.06	-0.09	-0.08	0.14	0.13	0.11	0.00	0.12

Data source: G-Cubed model simulation

A.5 **Scenario E: change in real consumption relative to scenario A** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	1.19	-1.15	-1.10	-1.05	1.89	2.32	2.50	1.59	8.35
Japan	-0.03	0.10	0.09	0.05	-0.57	-0.24	-0.19	-0.08	-0.41
Australia	0.02	-0.13	-0.11	-0.08	0.21	0.12	0.09	0.01	-0.11
New Zealand	-0.02	-0.02	-0.01	0.00	0.01	0.02	0.02	0.00	0.00
Canada	0.08	-0.56	-0.43	-0.34	0.58	0.33	0.17	-0.03	-1.30
Europe	0.86	-0.70	-0.78	-0.82	0.83	0.18	-0.16	-0.84	-5.50
China	0.10	0.07	-0.04	-0.12	0.03	-0.13	-0.20	-0.18	-1.64
non oil LDCS	-0.02	0.92	1.00	1.03	0.07	0.10	0.11	0.40	6.33
EEFSU	0.69	-1.30	-1.25	-1.18	1.84	1.23	1.08	0.33	-0.73
World	2.87	-2.77	-2.62	-2.51	4.90	3.93	3.41	1.21	4.99
Annex B	2.79	-3.76	-3.59	-3.42	4.79	3.95	3.51	0.98	0.30

Data source: G-Cubed model simulation

A.6 **Scenario F: change in real consumption relative to scenario A** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	1.19	-1.15	-1.10	-1.05	1.89	2.32	2.50	1.59	8.35
Japan	-0.03	0.10	0.09	0.05	-0.57	-0.24	-0.19	-0.08	-0.41
Australia	0.02	-0.13	-0.11	-0.08	0.21	0.12	0.09	0.01	-0.11
New Zealand	-0.02	-0.02	-0.01	0.00	0.01	0.02	0.02	0.00	0.00
Canada	0.08	-0.56	-0.43	-0.34	0.58	0.33	0.17	-0.03	-1.30
Europe	0.86	-0.70	-0.78	-0.82	0.83	0.18	-0.16	-0.84	-5.50
China	0.10	0.07	-0.04	-0.12	0.03	-0.13	-0.20	-0.18	-1.64
non oil LDCS	-0.02	0.92	1.00	1.03	0.07	0.10	0.11	0.40	6.33
EEFSU	0.69	-1.30	-1.25	-1.18	1.84	1.23	1.08	0.33	-0.73
World	2.87	-2.77	-2.62	-2.51	4.90	3.93	3.41	1.21	4.99
Annex B	2.79	-3.76	-3.59	-3.42	4.79	3.95	3.51	0.98	0.30

Data source: G-Cubed model simulation

A.7 **Scenario G: change in real consumption relative to baseline** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	69.84	123.62	158.02	184.44	151.60	143.28	133.73	208.00	1806.05
Japan	-19.77	-35.15	-43.50	-48.07	-43.47	-49.66	-51.75	-65.81	-563.08
Australia	-0.91	-0.58	-0.36	-0.18	-5.09	-4.47	-4.67	-1.32	-23.77
New Zealand	-0.69	-0.94	-1.00	-1.02	-1.10	-1.03	-0.83	-0.04	-9.68
Canada	-9.38	-14.01	-15.33	-15.10	-30.11	-28.96	-28.30	-20.00	-237.71
Europe	-81.16	-135.51	-169.52	-192.60	-242.85	-257.17	-272.68	-286.43	-2537.48
China	-12.35	-25.07	-32.45	-36.38	-39.77	-39.61	-39.74	-43.27	-416.21
non oil LDCS	72.11	121.40	149.49	167.26	190.96	200.92	208.81	212.84	2056.64
EEFSU	-6.87	-6.94	-7.18	-7.27	-3.04	-1.54	0.12	-5.36	-55.59
World	10.82	26.83	38.18	51.08	-22.87	-38.24	-55.32	-1.39	19.17
Annex B	-48.94	-69.49	-78.87	-79.80	-174.06	-199.55	-224.39	-170.96	-1621.25

Data source:G-Cubed model simulation

A.8 **Scenario H: change in real consumption relative to scenario G** $US billion 1996

	2000	*2002*	*2004*	*2006*	*2008*	*2010*	*2012*	*2020*	*Cumulative 1999 to 2020*
USA	4.68	-4.66	-15.03	-28.35	11.30	16.61	19.91	12.86	25.28
Japan	0.47	1.26	1.36	1.16	-5.95	-1.38	-0.82	-0.08	0.71
Australia	0.00	-0.98	-1.67	-2.19	2.45	1.19	0.95	0.03	-2.84
New Zealand	-0.10	-0.16	-0.18	-0.10	0.10	0.19	0.19	0.02	-0.01
Canada	-0.06	-3.55	-5.62	-7.24	7.20	4.29	2.45	-0.18	-12.05
Europe	2.03	-4.79	-9.99	-15.75	13.50	7.97	5.50	-1.34	-26.99
China	-0.08	-0.31	-0.34	-0.41	0.84	-0.51	-1.20	-1.28	-9.45
non oil LDCS	0.13	3.25	6.16	9.13	-1.08	-0.86	-1.20	0.54	27.86
EEFSU	-0.29	0.56	1.33	1.98	-1.94	-1.18	-1.13	-0.30	1.10
World	6.79	-9.38	-23.96	-41.78	26.42	26.32	24.65	10.26	3.62
Annex B	6.75	-12.32	-29.79	-50.49	26.66	27.69	27.05	11.01	-14.79

Data source: G-Cubed model simulation

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