Ministry for the Environment

The Economic Effects of Low-level Carbon Charges

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Contents

Executive Summary

The report presents a general equilibrium analysis of some low level carbon charges under an indicative range of alternative options for revenue recycling. It has been commissioned by the Ministry for the Environment on behalf of the Pre-2008 Cross-Sectoral and Price Measures Working Group of the New Zealand Climate Change Programme. The report is not a comprehensive analysis of policies to reduce CO_2 emissions, nor does it make specific recommendations about tax policy in general.

Three rates of carbon charge are examined; $10, $30, and $50 per tonne of carbon, corresponding to $2.73, $8.19 and $13.65 per tonne of CO_2 respectively. The different uses of the resultant revenue which are analysed are: repayment of government debt, lower petrol excise tax and no ERL on coal, lower corporate tax, lower GST and a lower top rate of personal income tax.

Analysis of the different carbon charge rates, for a given type of revenue use, shows that the carbon charge is non-linear in its effects. At $10/tonne the level of CO_2 emissions declines by 1.2%, but five times this level of carbon charge leads to a decline in emissions which is only 4.1 times greater at 4.9%. This is to be expected as reducing emissions becomes progressively more costly as the economy moves up the abatement cost curve.

Carbon charge revenue used to repay debt

Repaying debt with the revenue from the carbon charge leads to a reduction in all of the measures of macroeconomic activity – GDP, private consumption, exports, employment and so on. This is felt by almost all industries. Not surprisingly Coal Mining suffers the largest decline in output; 10% under the $50 carbon charge. Energy intensive industries such as Iron and Steel also experience notable declines in output. At the household level, poorer groups are worst affected as they spend proportionately more on energy than richer households.

Carbon charge revenue used to reduce existing taxes ("revenue recycling")

The main objective in selecting the revenue recycling scenarios discussed in this report was to examine the implications of revenue recycling for a broad range of taxes with differing incidences and efficiencies. The choice of scenarios does not indicate Government policy or constitute a recommendation.

General aggregate economic impacts

Altering what is done with the revenue from the carbon charge (recycling) has some significant effects. Although many of the effects at the macroeconomic level are not statistically significant, private consumption rises under all options except under lower corporate tax. Gross Domestic Product shows at least a small rise in every case.

Distributional effects – household income groups

Generally, revenue recycling tends to deliver a relative benefit to poorer households, partly because of employment assumptions made in the model, although the effects are small. The carbon charge raises around $270m in revenue of which only about $30m is paid directly by households. As this constitutes less than 0.05% of total household consumption, large distributional effects should not be expected.

Industry-level output effects

The same argument applies to most of the industry level changes. With the exception of the electricity generation and energy intensive industries, the carbon charge represents only a small shock to the wider economy. Thus the changes in industry gross output are usually well under ±1%.

Competitiveness effects

Changes in the share of the New Zealand market held by domestically produced goods versus imported goods are generally imperceptible outside base metal products. Again the shock of the charge is small, representing about 3% of the total tax paid by the business sector and only about 0.1% of the value of total gross output.

Export volumes by industry type exhibit somewhat more variability than the domestic market share ratios, but generally follow the pattern of change in industry output levels under each scenario. Hence the effects on New Zealand's competitiveness of a carbon charge are more likely to be manifested on the export side of the international trade ledger than on the import side.

Discussion of individual recycling options

GST (fixed real wage assumption)

The most positive recycling option is the reduction in GST, but a cautious interpretation is required here. The gain in macroeconomic activity comes about because of the increase in employment of nearly 0.4% (implying almost 6000 full time equivalent jobs). This in turn is generated by the increase in competitiveness brought about by the fall in wage rates – a fall relative to what would occur in the absence of a carbon charge, not necessarily a fall relative to the present. The fall in the wage rate is a consequence of the labour market closure assumption which stipulates that the real income wage rate should not change as a result of a carbon charge. When GST is reduced a lower nominal wage will suffice to maintain a given real wage. Hence the improved competitive position and the increase in employment.

GST (fixed employment assumption)

The dependence of the above result on the labour market closure assumption is illustrated by the results of another scenario, where under the same recycling option employment is held constant and the real wage rate is free to vary in response to the policy shock. There is still an increase in consumption, but exports decline and GDP shows virtually no change.

Which labour market closure rule is more appropriate depends on both the time horizon under consideration (with shorter horizons being more consistent with fixed real wages) and one's view about the degree to which government policy, and CO_2 policy in particular, is capable of affecting the long run rate of employment. In most cases some intermediate position probably prevails.

Corporate income tax

Reducing the corporate tax rate has the lowest positive impact on GDP out of the four revenue recycling options, but it is less dependent on the labour market closure assumption. The only macroeconomic variable which reacts to any significant degree is gross investment. However, the model knows nothing about the quality of that investment. If the incremental investment is in improving energy efficiency the model may be understating the benefits from lowering the corporate tax rate.

Personal income tax

Reducing the top rate of personal income tax presents a more balanced macroeconomic picture in the sense that it does not focus the output gain from tax re-balancing on either consumption (which the reduction in GST does) or on investment (which the reduction in corporate tax does). It does, however, squeeze the relative consumption position of the second and third highest household quintiles. This is because the bottom two quintiles gain more from increased employment opportunities whilst the top quintile gains more from the tax cut.

Energy taxes

This scenario examines the implications of using revenue from the carbon charge to abolish the ERL on coal and reduce the petrol excise tax but does not rebalance other taxes or charges on other transport fuels. Using the revenue from the carbon charge to abolish the ERL on coal and reduce the petrol excise tax leads to a much smaller reduction in emissions. In fact the reduction in the petrol price made possible by the recycling exceeds the increase forced by the carbon charge. Thus in net terms the price of petrol declines. This has a beneficial effect on poorer households in particular as it compensates them for higher gas and electricity costs. The reduced pressure on consumer prices generally and thus on wages, leads to higher employment and higher real private consumption.

Conclusions

Overall we may infer that a low level carbon charge does not have dramatic distributional effects on either households or industries. A small group of industries, however, suffers reductions in output that are one to two orders of magnitude greater than the norm. There may be ways whereby these industries can contribute to reducing emissions without having to incur such contractions, although this is beyond the ambit of the report; as noted at the start, the report does not aim to ascertain the optimal policy means of reducing the CO_2 emissions. Neither has it set out to develop the ideal tax regime.

The results suggest that there may be a small macroeconomic gain from imposing a low level carbon charge, provided that the revenue is used to reduce other taxes. This result is stronger under the assumption that wage rates change in line with consumer prices, than under the assumption that they change to equilibrate supply and demand.

It should be noted, however, that all of the results are based on a “comparative dynamic” framework. That is, whilst the model incorporates a requirement to accumulate capital stock to support economic growth beyond the year being modelled, it does not explicitly incorporate the time path of investment decisions and adjustments to policy shocks. Neither does it account for the transactions costs of the different recycling options (although such costs could be simulated if the required information was available). Therefore results which show very small macroeconomic changes may not be statistically significant.

The Economic Effects of Low-level Carbon Charges

1. Introduction

This report has been commissioned by the Ministry for the Environment on behalf of the Pre-2008 Cross-Sectoral and Price Measures Working Group[1] of the New Zealand Climate Change Programme. The purpose of this report is to provide information on the distributional, competitiveness and industry level effects of various low levels of taxation on CO_2 emissions under different options for revenue recycling. That information will contribute to the preparation by officials of a broader report to the Minister of Finance and the Tax Review 2001 regarding the possible impacts of a carbon charge on the New Zealand economy.

In particular, this report has been commissioned to examine the following questions in relation to a carbon charge:

a) What are the likely distributional effects of a carbon charge, and what drives those effects?

b) What are the likely competitiveness effects of a carbon charge on New Zealand industries, and what drives those effects?

c) What are the other effects of a carbon charge on industry sectors, including their greenhouse gas emission levels, and what drives those effects?

d) How are the findings above offset or affected by revenue recycling, and why does this occur?

The report addresses these questions through the use of eight scenarios to examine the impacts of different carbon charges and changes in other types of taxation on the New Zealand economy, using a 32-industry static computable general equilibrium model (outlined in Appendix A).

However, it is important to note that this is a technical report that provides information on economic indicators, but which is intended neither to provide a definitive analysis of options to reduce CO_2 emissions, nor to provide recommendations about tax policy reform.

As such, it should be understood that the changes specified to different levels and types of tax under each scenario are intended to show the sensitivity of impacts to changes in different types of taxation, but are not intended to represent taxation policy proposals.

[1] The agencies represented on the Working Group are theMinistry for the Environment, Treasury, Energy Efficiency and
Conservation Authority, Ministry of Economic Development and the
Ministry of Agriculture and Forestry. The other agencies in the NZ
Climate Change Programme are the Department of Prime Minister and Cabinet,
the Ministry of Transport, Te Puni Kokiri, Ministry of Research, Science
and Technology, Ministry of Foreign Affairs and Trade, and the
Department of Internal Affairs (Local Government Division).

2. Scenario Outline

Eight policy variations on the Business as Usual scenario are considered. Their specification is as follows:

Business as Usual (BAU) – A projection of the economy to 2005/06 with no carbon charges. See Appendix B for further details. Note that the 2005/06 projection is a snapshot of the economy at that point in time. No transition path is identified.

The first three scenarios look at different levels of a charge on CO_2 emissions. The rates of carbon charge modelled in these scenarios were based on the range of carbon prices identified in models estimating the international carbon price during the Kyoto Protocol commitment period (2008-2012). The rates identified represent low-level carbon charge rates.[2]

Run 1 – Imposition of a charge on CO_2 emissions of $30/tonne of carbon, equivalent to $8.19/tonne of carbon dioxide. The revenue is used by the Government to repay debt. Real wage rates are fixed at BAU levels so that employment is endogenous.

Run 2 – As in Run 1 with the carbon charge set at $10/tonne of carbon.

Run 3 – As in Run 1 with the carbon charge set at $50/tonne of carbon.

The following five scenarios explore the effects of alternative recycling assumptions for the Run 1 charge of $30/tonne of carbon.

Run 4 – As in Run 1 with the Energy Resources Levy on coal set to zero, and (non-dedicated) petrol taxes reduced such that the carbon charge is fiscally neutral.

Run 5 – Analogous to Run 4 with revenue recycling via lower corporate taxation. Note that the model uses the effective rate of corporate taxation, not the statutory rate.

Run 6 – Analogous to Run 4 with revenue recycling via a lower rate of GST.

Run 7 – Analogous to Run 4 with lower personal income tax; in particular a lower top rate. Note that as with corporate tax the model works on effective tax rates, not statutory tax rates. Also, the household sector is disaggregated by household income quintile, not by individual income. Thus it has been necessary to estimate the proportion of people in each quintile who pay the top tax rate and determine the effects of this on each quintile's overall effective tax rate. Details are given when the scenario is presented.

Run 8 – As in Run 6 with an alternative labour market closure assumption; the total level of employment is fixed at the BAU level so that wage rates are endogenous.

[2] The lowest rate modelled here has a value approximately half that of the lower bound of the expected commitment period range of international carbon prices, while the highest rate modelled here is at approximately the lower quartile of that range, in present value terms.

3. Results

The results are presented and discussed in the sections set out above. We look firstly at different levels of a carbon charge in Runs 1-3. The macroeconomic results are summarised in Table 1, and are expressed as differences in relation to the BAU scenario. Industry specific data on CO_2 emissions, gross output, and domestic market shares are given in Appendices C, D and E respectively. Exports by commodity are shown in Appendix F.

Note that the percentage changes in Table 1 are not accurate to the two decimal places shown. This degree of detail is presented so that small non-linearities are not lost in rounding. In fact changes less than 0.1% (at minimum) may not be reliable.

3.1 Alternative carbon charge rates

The imposition of a carbon charge leads to a small decline in macroeconomic activity. A carbon charge of $10/tonne of carbon leads to a reduction in GDP of 0.02%, but five times the charge at 50/tonne leads to a proportionately greater fall in GDP of 0.13%. A similar non-linear effect occurs with respect to the decline in emissions.

The fall in private consumption of 0.13% in Run 3 corresponds to about $22 per capita. Employment declines by nearly 4,700 FTE to accommodate the downward pressure on the real wage rate, which is one reason why the fiscal surplus does not actually increase by the full amount of revenue obtained from the carbon charge. That is, more people are paid the unemployment benefit and at the same time there is a fall in income tax revenue. Thus a considerable proportion of the revenue from the carbon charge has to be used to counter its negative macroeconomics effects, before any government debt can be repaid. Similarly, in the recycling scenarios considered below it is the actual surplus which is used to lower other taxes, not the revenue directly received from the carbon charge.

Table 1
Alternative Carbon Charges

	BAU	**Run 1**	**Run 2**	**Run 3**
		$30/tonne C	$10/tonne C	$50/tonne C
			% change on BAU	
Private consumption ($m)	67891	-0.09	-0.02	-0.13
Gross investment	26807	-0.04	-0.01	-0.05
Exports	43534	-0.18	-0.05	-0.28
Imports	41318	-0.12	-0.04	-0.19
Gross domestic product	113756	-0.09	-0.02	-0.13
Employment ('000)	1578.0	-0.15	-0.05	-0.24
Real exchange rate (index)	1.000	0.04	0.01	0.07
Consumer prices (index)	1.000	-0.02	-0.01	-0.03
CO_2 emissions (Gg)	34056	-3.20	-1.19	-4.89
- as a percentage of 1990	134.1	129.8	132.5	127.5
Carbon charge revenue ($m)	0.0	270.0	91.9	441.8
Actual change in fiscal surplus ($m)	–	178.1	61.3	294.4

Emissions of CO_2 fall by between 1.2% and 4.9% depending on the rate of the carbon charge. With the charge at $50/tonne of carbon the growth in emissions from 1999/2000 declines from 1.8% pa in the BAU scenario to 1.0% pa. Another way of looking at this is to note that in the BAU scenario emissions are projected to be 134.1% of what they were in 1990,[3] but that this ratio falls to 127.5% under Run 3. Thus a charge at $50/tonne of carbon removes about 20% of the projected increment in CO_2 emissions relative to 1990.

Appendices C-F on industry level impacts show a number of interesting results:

- Whilst thermal generation of electricity shows the expected decline, renewables generation also declines slightly. This is because the demand for electricity declines as part of the shift away from energy and energy intensive products. Note that as with all of these changes, the decline in renewables generation is in relation to the BAU, not in relation to 1999/2000. Thus it actually corresponds to a reduction in the rate of construction of new capacity from 1999/2000, although it is beyond the detail of the model to further split reduced growth into hydroelectric versus geothermal increments.

- The industries with the largest proportionate reductions in their emissions are Textiles, Private Services, Coal Mining (emissions generated by the industry in all of its activities – not from the combustion of coal), Food Processing, and Cement. It seems that these industries are more readily able to switch to less carbon intensive fuels, although it would be worthwhile to test the robustness of this result by changing the elasticities of substitution between energy and other inputs and between the different types of energy.[4]

- In general industrial output falls with the imposition of a carbon charge, but there a few industries which go against the trend, notably Other Agriculture (horticulture etc), Forestry, Wood Processing and Other Manufacturing. These industries experience higher export growth, which is counter to the general movement in exports. The cost-increase effect of the carbon charge is outweighed by the lower user cost of capital, which falls because of the imposed constraint that the capital stock is fully employed across all scenarios. (This is a standard closure mechanism in general equilibrium modelling, reflecting the assumption that the long run rate of capacity utilisation and capital formation is independent of policy shocks such as carbon taxes. Of course in the short term this may not be the case, but modelling short term transition paths is beyond the capability of this version of the model).[5]

- In addition, the forestry industries gain some market share in the demand for investment goods at the expense of more energy intensive investment goods made with steel and aluminium.

With respect to market penetration by imports the carbon charge does not have any marked effects – see Appendix E. The largest changes occur in base metals, but even here the loss of market share to imports in Run 3 is only about 1-2 percentage points. Even the Petroleum industry loses only 0.5 percentage points of the total market demand to imported product. It

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[3] *National Inventory Report*, Ministry for the Environment, April 2001.

[4] Although most of the elasticity values are taken from international econometric studies, one may well question how applicable they are to New Zealand industries such as Cement. Certainly for one the country's two cement plants there would appear to be little scope to use any fuel other than coal. However there is considerable literature on reducing energy in the cement industry. See for example http://www.cerf.org/evtec/eval/cement and http://www.cementnik.com

[5] A small 7-industry dynamic version of the model could be of use here.

releases CO_2 as part of the refining process, which places it at a small disadvantage to imported product. However, whilst these changes are small there is little doubt that under a higher carbon charge the effects would be much more pronounced.

The effects on the household sector are discussed in more detail in Section 3.4, but there are two key messages conveyed by the results. Firstly, if the revenue is used to repay government debt, a carbon charge shifts income and consumption from poorer households to richer households. This is because poorer households spend a larger proportion of their budget on energy. Secondly, whilst the direction of the relative shifts in income and consumption is clear, the size of the effects is very small. With total private consumption being over $67,000m and revenue from the charge being only about $270m (not all of which is paid by households) small distributional effects should not be surprising.

3.2 Alternative recycling

In the following five scenarios we examine how the effects of a carbon charge differ – macroeconomically and distributionally – if the revenue raised by the charge is used to reduce other taxes, instead of being used to repay government debt. As noted in the Introduction these options are not intended to ascertain the optimum method of recycling, nor to recommend any particular recycling policy. There is a whole range of other options which are not examined, such as compensatory welfare payments to poorer households, energy efficiency incentives, development of CO_2 sinks and containment technologies, and so on. Also there is no consideration in the model of the transactions costs associated with different recycling regimes. For example repaying government debt is easier than changing income tax rates.

Run 4 (recycling via lower petrol excise tax)

Table 2 shows that how the revenue from the carbon charge is recycled can be seen to have a strong effect on the macroeconomy – in a relative sense. In Run 4, the revenue is used to abolish the ERL on coal and to reduce the non-dedicated portion of petrol excise tax.[6] The numbers are such that most of the revenue from the carbon charge on coal and gas is used to reduce the petrol excise tax, as the ERL on coal raises little revenue. Thus the petrol price actually falls; the initial price-raising effect of the carbon charge being more than offset by the reduction in excise tax. The size of the fall is estimated to be approximately 10c/litre, which translates directly into a fall in the price at the pump. The Petroleum industry not only regains, but increases its share of the total petroleum products market by about 3%.[7]

The reduction in the petrol price also lowers the rate of consumer price inflation and thus the pressure on wage rates which, given the labour market closure assumption, generates an increase in employment. In relation to Run 1 the increase is about 4,000 FTE, sufficient to raise real private consumption even above the BAU level. Poorer households are particular beneficiaries, gaining additional income from employment and facing lower costs for petrol

[6] The modelling run is based on the current level of petrol excise being paid, however it should be noted that the amount of petrol excise recovered is continuing to decrease due to improved vehicle efficiency and new technologies. Increases in fuel efficiency and new propulsion technologies are likely to mean that, in the long term, fuel excises will need to be replaced by direct user charging systems (such as the current Road User Charges for diesel vehicles).

[7] This result is largely an artifice due to aggregation bias which causes all output from the Petroleum industry (not just petrol) to experience a fall in price and thus an increase in demand.

(see Section 3.3 for more detail). Thus a reallocation of taxation away from discriminatory petrol taxes towards a uniform carbon charge is welfare enhancing relative to Run 1, although is less effective in terms of CO_2 emissions.

Because the petrol price drops relative to the BAU scenario, the decline in the demand for petrol which occurs in Run 1 no longer occurs. Indeed demand rises relative to the BAU. Not surprisingly therefore the reduction in emissions achieved in Run 1 is compromised, being only about one third of that achieved in Run 1.

Run 5 (recycling via lower corporate tax)
Recycling via a lower tax on corporate income produces a rather different picture. As noted above, the model only knows about the effective rate, not the statutory rate of corporate income tax. The effective rate is defined as the amount of corporate tax actually paid, divided by operating surplus, after deductions for depreciation and net interest payments. This simplification misses some of the detail that occurs in reality, but most of this is not relevant to medium term structural modelling.

The estimated effective rate in the model's base year and as projected for the BAU scenario is 10%. In Run 5 this declines to 9%. This might be equivalent to a reduction in the statutory rate from 33% to around 30%, but probably implies a bigger fall. Whatever the case, the effect is improved post-tax earnings. Some of it is distributed to households and this helps to reduce the downward effect of the charge which is evident in Run 1. Private consumption shows a small decline and this effect is fairly uniform across the household income quintiles.

Nevertheless, the dominant effect is a movement of resources to the corporate sector. This leads to a small expansion in activity as a result of greater investment. If the extra investment enhances the introduction of new technology, especially energy efficiency technology (as a reaction to the imposition of a carbon charge), this recycling option may produce greater benefits than have been modelled here.

Although the real exchange rate declines in relation to the BAU, the change is insufficient to produce a lift in total exports. As may be seen in Appendix F, this is because the drop in exports of aluminium and steel caused by the carbon charge, outweighs the favourable effect of the lower capital costs on the other industries. In subsequent scenarios it will be seen that the change in the real exchange rate is more significant because of a stronger influence from labour costs.

There is also much less undermining of the reduction in emissions than occurs under Run 4.

Run 6 (recycling via lower GST)
Run 6 with GST recycling is in some ways a combination of Runs 4 and 5. Like Run 5 it retains most of the reduction in CO_2 emissions that is originally achieved in Run 1, and like Run 4, the lower pressure on consumer prices generates an increase in employment via the real wage effect, as the pressure on the real wage rate is clearly positive. The latter effect, however, is much stronger in than in Run 4, as the full effect of the lower GST is manifested directly in consumer prices rather than, as occurs under a lower petrol tax, part of the benefit being transmitted indirectly via the prices of other goods and services.

Employment rises by 0.38% over the level in the BAU, equivalent to approximately 5,900 FTE jobs. Gross Domestic Product and private consumption show similar proportionate changes, with lower income households being the most notable beneficiaries. Their shares of consumption spending rise because they gain relatively more from the increase in employment.

The reduction in the rate of GST which can be accommodated is 6.4%, implying a drop in the actual rate from 12.5% to 11.7%.[8] This is more than is implied by the revenue directly earned from the carbon charge. The reason is just the reverse of the situation in Run 1, where the Government's fiscal position improves by less than the revenue from the carbon charge. A reduction in GST means that a smaller increase in nominal wage rates can be accommodated for a given real wage rate. Thus labour costs to industry are lower, leading to an increase in competitiveness (as reflected in the lower real exchange rate), higher exports, more employment and so on. This results in more tax revenue for the Government and less expenditure on unemployment benefits. Thus fiscal position improves which widens the scope for tax cuts, which further increases activity and so on (although the process does converge).

Nonetheless, whilst this scenario has some obvious appeal, the effect of the labour market closure rule is important here. In particular, it is this closure rule which is responsible for a reduction at the margin of a broad based tax (GST) and its replacement with a relatively narrow based tax (on CO_2 emissions), leading to an increase in economic welfare. Microeconomic theory tells us that a broad based tax is more efficient and so should lead to a smaller loss in welfare than a narrow based tax. This effect is present in the model, but it is offset by the expansionary effect of the labour market closure rule. In Run 8 we look at changing the closure rule.

Run 7 (recycling via a lower top personal income tax rate)
In Run 7 recycling is via personal tax rates, notably via a reduction in the top rate of 39%. As noted above, the model deals with effective tax rates by household quintile so in order to simulate the effect of a lower top rate of tax we have had to estimate its incidence by household income quintile. We estimate that complete abolition would reduce the average effective tax rate on the top quintile by 0.98 percentage points, and that of the second highest quintile by 0.01 percentage points.[9] No other quintile would be affected. For modelling purposes therefore we ignore the second highest quintile and solve for the effective tax rate on the top quintile.

The effective tax rate on the top quintile falls by 3.97%, which is consistent with a fall in the top income tax rate of 39% to 33.04%. Given the error in the calculations we may infer that the top rate could essentially be abolished. Although the carbon charge only raises about $270m, the general expansion of the economy as a result of the tax reduction permits a reduction in the tax paid by the top quintile of about $410m.[10]

The reason for the expansion in economic activity is fundamentally the same as in Run 6. A reduction in income tax means that a smaller increase in nominal wage rates can be accommodated for a given real wage rate. Thus labour costs are lower, leading to an increase in competitiveness and greater employment. The labour market closure mechanism works on the average net income wage, and the 4% reduction in the tax burden on the top quintile implies a 0.6% reduction over all quintiles. Hence the cost of labour falls by an average of 0.6%. Again the lower quintiles are the main beneficiaries of the rise in employment and this

[8] In practical terms, it is unlikely that the GST rate would ever be levied at this rate; it is just what is implied by this particular recycling scenario. The purpose of this modelling is to illustrate the sensitivity of possible carbon charge impacts to changes in other taxes, rather than to present taxation policy proposals.

[9] We have used data from the Household Expenditure Survey for this purpose. However, the latest survey relates to 1998, before the 39% tax rate was introduced. Thus its estimated incidence is rather approximate.

[10] This is lower than what the Government estimated as the increase in revenue from raising the top tax rate (Budget 2000, B3, 15 June 2000, p20), probably because of its derivation from HES data.

underpins an increase in their consumption. With the consumption of the top quintile also rising (as they benefit from the tax cut) it does not come as a surprise to see that the consumption shares of the second and third highest quintiles declines.

There is an implicit assumption here that relative wage costs as faced by employers are maintained across different salary (say occupational) groups. Thus any downward pressure on the cost to employers of one group will be transmitted to other groups (subject to overall labour supply and demand), even though this implies different net income wage relativities. Given that the effect in this scenario is from the higher paid groups to the lower paid groups, this assumption seems plausible, but clearly the model would need to incorporate more than one type of labour if the wider implications of the assumption were to be seriously challenged.

Also, one might contend that maintaining real purchasing power is less of an issue in wage determination for those in the top income groups than for the labour force in general. If so then the increase in employment and in economic activity generally would be overstated. The model is not sophisticated enough to readily accommodate different labour market closure rules for different groups of earners, but the effect of a different closure rule for all earners is examined in Run 8 under the GST recycling option.

The GST and personal income tax options (Runs 6 and 7 respectively) are reasonably similar, with perhaps the most difference occurring in investment. This falls in Run 6 because of the lower price of consumption, which raises the opportunity cost of saving. In contrast there is no such relative price change in Run 7. And the higher propensity to save of the top household income quintile (who receive the tax cut) also helps to maintain investment. Thus in a macroeconomic sense, Run 7 presents a more balanced picture than the other scenarios – it does not display the relatively large reallocation of resources into consumption evident in Run 6, nor the reallocation of resources into investment evident in Run 5. Furthermore, most of the reduction in carbon emissions which occurs in Run 1 is maintained; emissions fall by 2.9% in Run 7 and 3.2% in Run 1.

Runs 4-7, notwithstanding some differences between them, present a picture which contrasts quite markedly with Run 1. Recycling the revenue from a carbon charge via a reduction in other taxes delivers a better macroeconomic outcome that using the revenue to repay government debt. Is this result due to the omission of forward-looking effects in the model?

The argument is that by repaying debt in some given year the Government is able to lower taxes in the future. Households know this and would therefore increase their spending in anticipation of those lower taxes, thereby offsetting the contractionary effect of the carbon charge. This effect is known as Ricardian equivalence – it may or may not prevail.[11] The model does not take it into account.

The key difference between Run 1 and the other scenarios is that in Run 1 the proportion of the economy accounted for by government expands because the total tax burden rises. This leads to usual losses in allocative efficiency associated with taxation. That the additional revenue is used to repay government debt does not alter this fact. Debt repayment is a capital account transaction, not an income and outlay account transaction. The position taken in the model is that the Government has some optimal level of debt, which is a function of (*inter alia)* the rate of economic growth, the rate of interest and the desired size of government. Using revenue from a carbon charge to repay debt would violate that optimality and thus

[11] Whether it prevails depends on factors such as the reputation and credibility of government, and on the degree of foresight by households.

merely lead to new debt being raised.[12] Thus the "Ricardian equivalence" effect does not apply.

Run 8 (recycling via lower GST, with fixed employment)
In Run 8 we repeat the GST recycling mechanism, but impose a fixed employment assumption. That is, employment is fixed at the level prevailing in Run 1, implying that all of the adjustment to the carbon charge in the labour market must be via real wage rates. In particular, given that employment rises in Run 6, we should expect to see a rise in the real wage rate when employment is fixed.

It is immediately apparent that macroeconomic effects are very different from those in Run 6. With the GST rate falling to 12.0% the real wage rate can still increase and does so by 0.21%, sufficient to deliver a small rise in private consumption. This is just sufficient to outweigh the negative change in exports and investment, in terms of the overall effect on GDP. Note that although a change of 0.03% is spuriously accurate ('no effect' would be a better conclusion), we should not expect the model to necessarily show an overall negative effect from replacing at the margin a broad based tax with a narrower one. As a maxim of tax policy it is generally true that a broad based tax is superior to a narrow based tax, but there are so many departures from the ideals of economic efficiency elsewhere in the economy that this maxim may fail at the margin – the "theory of the second best."

The outcomes in Run 8 are really too small to make robust inferences but it does appear that a very minor taxation shift away from GST towards a carbon charge, does not generate a decline in welfare, suggesting a linear 'tax indifference curve' at this particular combination of taxes. Whether this truly because of second best effects or because of "Ramsey effects" (whereby taxation of products with a low elasticity of demand leads to lower deadweight losses) is difficult to say.

For longer run horizons (of at least five years) the fixed employment assumption for closing the labour market is used more often by general equilibrium modellers, than the fixed real wage rate assumption. This is partly because use of the fixed employment assumption makes it easier to isolate the allocative effects of a policy change. It is also argued that the level of employment is ultimately determined by labour supply and demand, not by carbon charge policy – a reasonable enough stance, but not one which should be pursued too vehemently as it implies that no policies can ever affect the level of employment in the long run.

The two labour market closure rules are at opposite ends of a long continuum. Undoubtedly a more realistic assumption would lie somewhere in the middle. The results are strong enough, however, to suggest that even a weak positive relationship between wage rates (as seen by the consumer) and price movements would be sufficient to ensure a macroeconomic gain from a low level carbon charge, although over a longer time period than the 5-6 years we are considering here, that gain may well largely dissipate.

Given that the year 2005/6 would at most be only three years into a carbon charge regime, although presumably the announcement of a regime would effectively allow more time, the fixed real wage assumption is not unrealistic.

[12] If the initial size of government debt is not optimal, notably too high, a whole new dimension is introduced. In that case the issue becomes one of how best to regain the optimum, not what is the best use for carbon charge.

3.3 Household sector effects

Table 3 shows the effects of the carbon charge and the recycling options by household income quintile.[13] Quintile 1 is the lowest and 5 is the highest. Because most of the distributional effects are relatively small, summary measures such as the Gini coefficient are not presented.[14] The results are shown in terms of the shares of gross (pre-tax) income and consumption attributable to each quintile, as well as in terms of the percentage changes in the absolute levels (of gross income and consumption) relative to the BAU scenario. Note that all of these statistics relate to nominal dollars. For consumption the figures can be converted to real dollars by netting out the change in consumer prices – as given in Tables 1 and 2.

Looking firstly at Runs 1-3, it is evident that all quintiles incur reductions in consumption and income, reflecting the overall falls in private consumption shown in Table 1. However, the reductions are not uniform. The higher the carbon charge, the lower the proportions of total income and consumption secured by the lowest two quintiles – and conversely for the highest two quintiles. The reason for this is simply that poorer households spend a larger proportion of their budget on energy. This is confirmed in Run 4 where the reduced petrol tax leads to the lowest two quintiles increasing their share of income and consumption, and in fact leaves them relatively better off than under BAU scenario. Poorer households benefit more from the increase in employment in Run 4 than do richer households. The model allocates increases in employment in proportion to the distribution of those currently unemployed amongst the household income quintiles.

Recycling via lower corporate taxation (Run 5) reverses the absolute gains made by poorer households under lower petrol taxes, and reduces their relative gain, but still leaves them better off than under the debt repayment option assumed in Run 1. The biggest relative gains to the lowest two quintiles, indeed even including the middle quintile (just) occur in Run 6 under recycling via GST. These gains are driven primarily by the increase in employment, although the higher marginal propensity to consume of poorer households also contributes to their higher consumption shares.

Interestingly in Run 7 with the abolition of the top personal tax rate, the relative income position of the lowest two quintiles is only just a little worse than in Run 6, but their relative consumption position is almost identical to that in the BAU scenario. This is because although they benefit proportionately more than other quintiles from the rise in employment (thereby raising their shares of gross income relative to the BAU), the higher absolute level of spending by the top quintile (who receive the tax cut, in spite of some being saved) means that the absolute increase in consumption by the lower quintiles does not actually raise their share of consumption. In fact the consumption shares of the second and middle quintiles decline, and are lower than under any other scenario.

The importance of the incidence of the employment effects on the distributional outcomes is demonstrated in Run 8. The income and consumption shares are virtually identical to those in the BAU scenario as the lower quintiles cannot gain extra employment – as total employment is held constant. However, the small reduction in GST is just sufficient to restore the relative position of the lower quintiles from the adverse effects of the carbon tax (Run 1).

[13] Each quintile has its own income elasticity of consumption, but has the same price elasticity for each of the eight consumption goods identified in the model. However, as the composition of expenditure differs by quintile, the total price elasticity of consumption also differs by quintile.

[14] Another reason for not calculating Gini coefficients is that in some of the scenarios the underlying Lorenz curves cross, thereby invalidating a comparison of the associated Gini coefficients.

Overall then, as long as the revenue from a carbon charge is not used to repay debt, poorer households generally gain, or at least do not lose from a carbon charge – at least in a relative sense. Where they gain it is at the expense of the top two quintiles. Even when the top rate of income tax is cut the lowest two quintiles are not worse off., with the gain in the share of consumption secured by the top quintile coming at the expense of the second and middle quintiles.

Nevertheless, all of the changes in income and consumption shares are small. This is simply because the carbon charge raises only around $270m in revenue, and only about $30m of this is paid directly by households. As a proportion of total household consumption this is less than 0.05%. So not surprisingly there are no significant distributional effects generated by a carbon charge of $8.19/tonne of CO_2.

3.4 Industry level effects

In general the changes in industry output mirror the small changes at the macroeconomic level, but there exceptions. As was mentioned in Section 3.1, there are some industries which reduce carbon emissions quite substantially. In some cases the reduction in emissions is directly related to a decline in output; Coal Mining is the obvious example of this. In Run 3, the $50 carbon charge scenario, output and emissions from Coal Mining fall by over 10%. Iron and Steel shows a similar result.

In other industries such as Food Processing, Textiles, Cement, and Private Services, emissions fall by 9.8%, 14.7%, 9.9% and 10.1% respectively in Run 3, whereas gross output hardly changes. Thus these industries achieve their emissions reduction via fuel and input switching.

It was also noted that some industries benefit from a carbon charge. In Runs 1-3 these include Other Agriculture, Forestry and Other Manufacturing. For these industries energy is not a major input cost. Wood Processing also benefits; one reason for which is the lower exposure to carbon charges this industry has achieved in recent years with the increasingly common use of co-generation practices. It also benefits from a lower user cost of capital, brought about by the closure assumption that the capital stock must be fully utilised in all scenarios. This is reflected in exports of wood products which rise in Runs 1-3. Similarly for horticultural exports. Exports of chemicals (which excludes petrochemicals) and other services (such as education) also increase, but not by a sufficient amount to prevent overall declines in the output of the associated industries.

In the market for investment goods wood secures a price advantage over materials such as concrete and metals based products. The Iron & Steel, and Aluminium industries also face a small loss of domestic market share to imported products – see Appendix E. (There is an implicit assumption here that New Zealand can secure such products from countries who do not impose a charge on CO_2 emissions).

The relative industry level effects observed in Runs 1-3 largely carry over to Runs 4-8. There are, however, a few notable differences.

Coal exports rise dramatically – by 26% – in Run 4 when the ERL on coal is abolished. This means that instead of output falling by 7% as it does in Run 1, it rises by 3%. Run 4 also sees a rise in tourism exports which increase by 0.6% compared to a fall of 0.2% in Run 1. In fact the Transport and Petroleum industries are the other major beneficiaries of the recycling option examined in Run 4 – notwithstanding the artificial gain in domestic market share secured by Petroleum, as discussed above.

Under lower corporate taxes (Run 5) the results are as might be expected with all industries showing some benefit. In some cases this is sufficient to turn a loss in Run 1 into a gain. Examples include the two pastoral farming industries, Paper, Fabricated Metal Products, Trade and Finance.

Run 6 sees further expansions in industry output, with the only remaining output reductions being largely confined to the energy producing and energy intensive industries. Interestingly the only industry which fares worse in Run 6 than in Run 1 is Owner Occupied Dwellings. This is because its output, being an imputed output, does not attract GST. Therefore when GST is lowered other goods and services bought by consumers gain a price advantage. In addition the demand for housing is also related to the consumption-saving decision, and as noted above, the opportunity cost of saving rises when GST falls. In Run 8, with the smaller decline in GST, the Owner Occupied Dwellings industry just about breaks even.

Most of the other changes in industry output in Run 8 are around 0.3 percentage points lower than in Run 6, essentially reflecting the difference in the change in private consumption between the two scenarios. Emissions of CO_2 follow much the same pattern. With no change in relative energy prices between Runs 6 and 8 (excluding second order effects), the differences in emissions merely reflect the differences in output.

Under a reduction in the top rate of personal income tax (Run 7), the output of most industries lies between the levels achieved in Runs 5 and 6. The main exception to this is Fabricated Metal Products, for which output in Run 7 is higher than in Runs 5 and 6. Whilst it clearly gains from an increase in investment at the expense of consumption, which is what happens between Runs 6 and 7, investment is even higher in Run 5. What the industry could consequently be expected to gain under Run 5, is in fact more than offset by lower sales of intermediate goods to other industries. This is just an example of a positive substitution effect (more demand for investment goods) being countered by a negative expansion effect (lower GDP in Run 5 compared to Run 7. In Run 7 the labour closure assumption has a stronger effect than in Run 5.

Finally it is worth mentioning the market share ratios presented in Appendix E. Apart from the few instances mentioned above, the ratios show almost no variation between the scenarios. This is not a consequence of inflexibility in domestic-import substitution possibilities. On the contrary, most of the Allen elasticities of substitution vary between 1.5 and 3.5 in the model. The invariant ratios simply reflect the very low level of a possible carbon charge and the low energy content of most goods and services. We may infer from Runs 1-3 that the base metals industries would see a much larger loss in market share under a higher carbon charge. Some movement could also be expected with regard to industries such as Ceramics and Fabricated Metal Products. For other industries which currently have close to 100% of the domestic market there may be a trigger point at which domestic production becomes unprofitable and the entire market is lost to imports. Cement may be an example. Nevertheless it would appear that as far as the international competitiveness of New Zealand industries is concerned, the potential adverse effects of (low level) carbon charges are more likely to emanate from the export side than from the import side.

Table 2
Carbon Charge at $30/tonne Carbon and Alternative Revenue Recycling

	BAU	Run 1	Run 4	Run 5	Run 6	Run 7	Run 8
		$30/tonne Carbon and various revenue recycling options - % change relative to BAU					
		repay debt	no coal ERL, lower petrol tax	lower corporate income tax	lower GST	lower top rate of income tax	lower GST (fixed employ.)
Private consumption ($m)	67891	-0.09	0.18	-0.04	0.45	0.17	0.13
Gross investment	26807	-0.04	0.02	0.30	-0.14	0.17	-0.17
Exports	43534	-0.18	0.03	-0.02	0.14	0.09	-0.09
Imports	41318	-0.12	0.07	-0.02	0.07	0.05	-0.07
Gross domestic product	113756	-0.09	0.09	0.05	0.26	0.16	0.03
Employment ('000)	1578.0	-0.15	0.11	-0.03	0.38	0.29	0.00
Real wage rate index	1.000	0.00	0.00	0.00	0.00	0.00	0.21
Real exchange rate (index)	1.000	0.04	0.05	-0.05	-0.52	-0.12	-0.23
Consumer prices (index)	1.000	-0.02	-0.08	-0.08	-0.69	-0.06	-0.41
CO_2 emissions (Gg)	34056	-3.20	-1.15	-3.06	-2.79	-2.90	-3.06
- as a percentage of 1990	134.1	129.8	132.5	130.0	130.3	130.2	130.0
Carbon charge revenue ($m)	0	270.0	275.7	270.4	271.1	270.8	270.4
Actual change in fiscal surplus ($m)*	–	178.1	0.2	-0.2	-0.1	0.3	0.1

* Changes of less than $0.5m are within the error margin.

Table 3
Proportions of Gross Income and Consumption, and Changes in Absolute Gross Income and Consumption by Household Income Quintile

		Q1	Q2	Q3	Q4	Q5	Q1	Q2	Q3	Q4	Q5
BAU	Gross income	5.13	9.85	14.90	23.37	46.75					
	Consumption	10.74	12.40	16.82	23.88	36.16					
								% change on BAU			
Run 1	Gross income	5.11	9.83	14.89	23.39	46.78	-0.56	-0.49	-0.24	-0.12	-0.14
$30, repay debt	Consumption	10.73	12.37	16.82	23.90	36.18	-0.22	-0.35	-0.11	-0.01	-0.04
Run 2	Gross income	5.13	9.84	14.89	23.38	46.76	-0.18	-0.15	-0.08	-0.04	-0.05
$10, repay debt	Consumption	10.74	12.39	16.82	23.89	36.17	-0.07	-0.11	-0.03	0.00	-0.01
Run 3	Gross income	5.10	9.81	14.89	23.40	46.80	-0.90	-0.78	-0.39	-0.20	-0.23
$50, repay debt	Consumption	10.72	12.35	16.82	23.92	36.19	-0.35	-0.56	-0.17	-0.01	-0.07
Run 4	Gross income	5.14	9.87	14.90	23.36	46.72	0.29	0.24	0.06	-0.02	-0.01
$30, ↓ energy tax	Consumption	10.75	12.42	16.82	23.86	36.14	0.22	0.28	0.11	0.03	0.04
Run 5	Gross income	5.13	9.85	14.89	23.37	46.76	-0.13	-0.12	-0.07	-0.06	-0.03
$30, ↓ corp tax	Consumption	10.74	12.39	16.82	23.88	36.17	-0.14	-0.17	-0.13	-0.12	-0.09
Run 6	Gross income	5.18	9.92	14.91	23.33	46.66	0.50	0.33	-0.26	-0.53	-0.56
$30, ↓ GST	Consumption	10.80	12.48	16.83	23.83	36.05	0.35	0.37	-0.19	-0.44	-0.55
Run 7	Gross income	5.17	9.91	14.91	23.34	46.68	0.26	0.13	-0.32	-0.53	-0.55
$30, ↓ pers. tax	Consumption	10.74	12.39	16.75	23.72	36.40	0.10	0.08	-0.34	-0.54	0.78
Run 8	Gross income	5.13	9.85	14.90	23.37	46.74	-0.23	-0.23	-0.23	-0.22	-0.25
$30, ↓ GST	Consumption	10.75	12.40	16.82	23.88	36.14	-0.19	-0.26	-0.26	-0.26	-0.31

4. Further Research

Whilst conscious of the fact that this research is not aimed at producing policy recommendations on reducing CO_2 emissions, nor at promoting a particular tax regime, the robustness of any inference or conclusion is difficult to fathom without some sensitivity analysis of key assumptions and parameters. Runs 6 and 8 illustrate the importance of the labour market closure assumption to the results when recycling carbon charge revenue via a lower GST. Other testing would also be worthwhile. For example:

- Changing the factor input (KLEM) and energy mix (CONE) elasticities, especially in industries such as Cement and Food Processing which manage relatively large reductions in CO_2 emissions.

- Exempting process emissions from a carbon charge as the relevant industries may have little opportunity to change their production process.

- Changing the external balance closure rule by fixing the real exchange rate at the BAU level and letting the current account deficit be the equilibrating mechanism.

- Looking at broader based reductions in income tax.

- Recycling via grants to industry to be used for improving energy efficiency.

- Introducing more disaggregation of the energy and transport industries.

A more ambitious research programme would also address the issue of dynamics and adjustment periods. For short term policy horizons (less than about 5 years) this is especially important as the projected economic life and age profile of an industry's capital stock has a major effect on when it invests, and therefore on how quickly it can adapt to some form of charge on carbon emissions.

Appendix A: The ESSAM General Equilibrium Model

The ESSAM (Energy Substitution, Social Accounting Matrix) model is a general equilibrium model of the New Zealand economy. It takes into account all of the inter-dependencies in the economy, such as flows of goods from one industry to another, plus the passing on of higher wage costs in one industry into prices and thence the costs of other industries.

The ESSAM model has previously been used to analyse the economy-wide and industry specific effects of a wide range of issues. For example:

- Energy pricing scenarios
- Changes in import tariffs
- Faster technological progress
- Policies to reduce carbon dioxide emissions *(previously for the MfE)*
- Funding regimes for roading

Some of the model's features are:

- 32 industry groups, as detailed in the table below.
- Substitution between inputs into production - labour, capital, materials, energy.
- 4 energy types: coal, oil, gas and electricity, between which substitution is also allowed. In addition electricity generation is disaggregated into renewables based generation and thermal generation.
- Substitution between goods and services used by households.
- Social accounting matrix (SAM) for complete tracking of financial flows between households, government, business and the rest of the world.
- The household sector disaggregated into five income quintiles.
- Taxes levied at the appropriate stage in the production process. For example GST is levied entirely on final demand, petrol taxes at the point of sale and so on.

The model has a proven track record. In 1994 it was subject to external peer review by an international economic consultancy on behalf of the Ministry of Commerce. Some minor deficiencies were identified which were subsequently remedied.

The model's output is extremely comprehensive, covering the standard collection of macroeconomic and industry variables:

- GDP, private consumption, exports and imports, employment, etc.
- Demand for goods and services by industry, government, households and the rest of the world.
- Industry data on output, employment, exports etc.
- Import-domestic shares.
- Fiscal effects.

An additional advantage of using the ESSAM model is that its assumptions and input parameters are clearly transparent. All are open to amendment by the client. Transparency, the judicious use of sensitivity analysis, and careful interpretation of results, ensure that the model does not appear as a total black box.

The current version of the model is based on Statistics New Zealand's 1994/95 inter-industry tables. This is the latest available, although a comprehensive 1995/96 table is expected to be released around July 2001. From past experience we have not found the comparative old-age of these tables to be a major concern in policy analysis. We have updated the model's labour-output and capital-output ratios, relative world prices, its export mix and various selected energy use coefficients to a 1999/2000 base to reduce the likelihood of these key coefficients biasing our analysis.

Industry Classification
The 32 industries identified in the ESSAM model are defined below. Industries are now defined according to the Australian and New Zealand Standard Industrial Classification (ANZSIC). The 1994/95 input-output table, however, is based on the New Zealand Standard Industrial Classification (NZSIC). A concordance is available from Statistics New Zealand.

		NZSIC Number
1.	Sheep and Beef Farming	1112-1113
2.	Dairy Farming	1111
3.	Other Agriculture – Horticulture, Consultants etc	1114-1119,112 & 1132
4.	Fishing and Hunting	1131 & 13
5.	Forestry and Logging	12
6.	Coal Mining	21
7.	Crude Petroleum and Natural Gas Production	22
8.	Other Mining	23-29
9.	Food, Beverages and Tobacco	31
10.	Textiles, Apparel and Leather	32
11.	Wood and Wood Products	33
12.	Paper, Printing and Publishing	34
13.	Petrochemicals	351, 353, 354
14.	Chemicals, Rubber and Plastics	352,355,356
15.	Cement	3692
16	Ceramics, and Other Non-Metallic Minerals Products	36 excl 3692
17.	Basic Metal Industries – Iron and Steel	371
18.	Basic Metal Industries – Non-Ferrous	372
19.	Fabricated Metals, Machinery and Equipment	38
20.	Other Manufacturing	39
21.	Electricity Transmission & Distribution	4101
22.	Gas and water	4102-42
23.	Building and Construction	5
24.	Wholesale and Retail Trade, Restaurants and Accom.	6
25.	Transport and Storage	71
26.	Communications	72
27.	Finance, Insurance and Business Services	8 excl 83122
28.	Ownership of Dwellings	83122
29.	Private Services	92 – 95(excl. services provided by government)
30	Government Services	91 + Other 9 which are provided by government
31.	Electricity Generation - Renewables based	4101
32.	Electricity generation - Fossil Fuels	4101

Standard Elasticity Values

KLEM Allen elasticities of substitution (capital, labour, energy, materials):

	K	L	E	M
K	endog	0.65	0.50	0.40
L	0.65	endog	0.25	0.40
E	0.50	0.25	endog	0.60
M	0.40	0.40	0.60	endog

The above apply to all industries except Coal Mining, Hydrocarbon Mining, Petroleum, Iron & Steel, Electricity Distribution, Gas & Water Distribution, and Electricity Generation. Only labour-capital substitution is permitted in these industries - with a unitary Allen elasticity of substitution.

Within the composite energy input substitution occurs between four fuel types as detailed below. Within the composite materials input no substitution is allowed, although a unitary elasticity of substitution is an option.

Note that symmetry is imposed and that the values along the diagonal of the table vary from industry to industry in order to satisfy the homogeneity and adding up properties of a demand system.

CONE Allen elasticities of substitution (coal, oil, natural gas, electricity):

	C	O	N	E
C	endog	0.50	0.25	0.50
O	0.50	endog	0.50	0.25
N	0.25	0.50	endog	0.25
E	0.50	0.25	0.25	endog

The above apply to all industries except those listed above for which no intra-energy substitution is permitted. However, in thermal electricity generation substitution is permitted between coal and gas with an Allen elasticity of unity.

Households: The demand elasticities used in private consumption have been estimated using an Almost Ideal Demand System model based on data from the New Zealand Household Economic Survey.

Household Cross Price and Income Elasticities

	Food	Hsg	Hsehld Oprtn	Apparel	Trans-port	Tob & Alc	Other Goods	Other Servs
Food	-0.80	0.18	0.18	0.08	0.13	0.06	0.08	0.11
Housing	0.21	-0.80	0.17	0.07	0.14	0.04	0.07	0.10
Household Operation	0.20	0.16	-0.82	0.08	0.17	0.05	0.07	0.10
Apparel	0.21	0.14	0.18	-0.91	0.17	0.03	0.09	0.09
Transport	0.17	0.15	0.19	0.08	-0.75	0.02	0.06	0.09
Tobacco & Alcohol	0.24	0.15	0.19	0.05	0.06	-0.89	0.08	0.11
Other Goods	0.23	0.18	0.18	0.10	0.13	0.05	-0.97	0.11
Other Services	0.21	0.18	0.18	0.07	0.14	0.05	0.08	-0.90
Income Elasticities	0.71	1.21	0.63	0.89	1.23	1.12	1.00	1.12

In addition to these, substitution between energy and other items within the Household Operation category has an Allen elasticity of 0.40, and that between energy and other items within the Transport category an elasticity of 0.33. Within the energy input in Household Operation substitution is permitted between fuels with a uniform CONE elasticity of 0.33, whilst for energy into Transport substitution is permitted only between oil and natural gas products with an Allen elasticity of unity.

Appendix B: The 'Business as Usual' Scenario

The key input assumptions for the BAU scenario are shown in the following table. The domestic ones are drawn largely from Infometrics' short term forecasts for the next 2-3 years, whist the ones related to the international scene are based on OECD and World Bank projections.

The objective of the BAU scenario is to provide a plausible picture of the economy in 2005/06. It is not intended as a forecast, but rather as a reasonable basis against which various carbon charge options may be assessed. The strength of the model is in looking at comparative effects, that is at the differences between policy scenarios. In contrast the BAU scenario is only as good as the input assumptions. What is important is to ensure that there is nothing in the BAU scenario which has the potential to cause mischief when comparing alternative policy scenarios.

Table B1
'Business as Usual' Input Assumptions

	Variable	Value
1.	Real oil price	US$23/bbl.
2.	Employment	1.578 million full time equivalent jobs
3.	Population	4.01 million (SNZ series 3 to 2004/05 then series 4)
4.	Labour force .	2.10 million
5.	Total factor productivity	0.9% pa, industry mean
6.	Autonomous energy efficiency improvement	1.0% pa
7.	Capital stock growth	2.0% pa to 2004/05, then 2.5% pa.
8.	Real government consumption growth	1.9% pa to 2004/05, then 1.5% pa.
9.	Real government non-market investment growth	5.6% pa to 2004/05, then 2.0% pa.
10.	Fiscal surplus	$2000m (income tax rates adjust)
11.	External current account balance	3.1% of GDP (deficit)
12.	World export demand	4.6% pa
13.	Import tariffs	zero, except for apparel and footwear

In the other scenarios these variables are held constant, with the two exceptions:

- Employment is free to vary as real wage rates are fixed at whatever emerge from the BAU scenario.

- The fiscal surplus varies is allowed to increase in Scenarios 1-3, with the extra being used to repay government debt. Capital account transactions are not simulated in the model.

Note also that the external current account balance is maintained by adjustment of the real exchange rate.

The results are shown in Table B2. Growth in GDP over the next six years is projected to be 2.5% per annum. The period is characterised by slow growth in private consumption, with resources flowing into the export sector - a necessary adjustment to the present deficit in New Zealand's current account. The growth in exports is attributable to a lower exchange rate (especially over the immediate future), higher commodity prices and expected better growing seasons for agricultural products. In spite of the lower exchange rate import penetration continues to increase so the outlook for industries which supply the domestic market is not buoyant.

Table B2
'Business as Usual' Projection to 2005/06
($m 1994/95)

	1999/00	2005/06	% ch pa 2000-2006
Private Consumption	61339	67909	1.7
Government Consumption	14998	16731	1.8
Investment	23020	26817	2.6
Exports	32627	43534	4.9
Imports	34749	41318	2.9
GDP	98166	113756	2.5
Employment (FTE '000)	1483.5	1578.0	1.0
Unemployment Rate	6.6%	6.7%	
CO_2 emissions (Gg)	30523*	34056	1.8

* December year 1999

Employment expands over the period, but not by enough to prevent a small rise in the rate of unemployment.

The growth in CO_2 emissions is 1.8% per annum. This is above the rate of about 1.2% pa which is implicit in the projections by the (then) Ministry of Commerce[15] and is in spite of the faster growth in GDP assumed by the Ministry. The main reason is our assumption that Methanex continues to operate at full capacity in 2005/06, with all production being methanol – none is synthetic petrol. It is further assumed that the extra gas required comes from fields other than Kapuni and Maui, implying no payment of the Energy Resources Levy on this gas.

There are also compositional differences in fuel mix that are attributable to differences between the ESSAM model and the Ministry's SADEM model. Another difference is with respect to transport. In the ESSAM model all private transport use by business and households is attributed accordingly. Thus the only emissions from the Transport industry are those relating to public transport. There are also some minor differences in the allocation of industrial process emissions.

The table below shows the pattern of emissions in 2005/06 as projected by the ESSAM model. Note that emissions released in the production of methanol and in the refining of petrol are attributed to the Petroleum industry, while the emissions due to combustion of petrol itself is attributed to the final using industry/household. Also, emissions due to venting and flaring are classed as process emissions, as is the release of CO_2 from geothermal generation.

[15] Ministry of Commerce, *New Zealand Energy Outlook to 2020*, February 2000, pp 37-39.

‘Business as Usual’ CO_2 Emissions in 2005/06
(Gg CO_2)

		Energy	Process	Total
SHB	Sheep and beef farming	189.00	0.00	189.00
DAI	Dairy farming	203.48	0.00	203.48
OAG	Other agriculture	227.80	0.00	227.80
FSH	Fishing and hunting	409.29	0.00	409.29
FOR	Forestry and logging	159.21	0.00	159.21
COA	Coal mining	0.00	83.74	83.74
GAS	Gas and oil exploration & production	0.00	404.71	404.71
MIN	Other mining	338.40	0.00	338.40
FBT	Food processing	2373.55	0.00	2373.55
TAL	Textiles and apparel	328.99	0.00	328.99
WOD	Wood processing	242.11	0.00	242.11
PAP	Paper and printing	539.37	0.00	539.37
PET	Petroleum	1278.40	0.00	1278.40
CHE	Other chemicals	311.41	0.00	311.41
CEM	Cement	719.41	642.35	1361.77
CER	Ceramics	273.17	0.00	273.17
FES	Iron and steel	1475.40	836.37	2311.78
ALO	Aluminium and other metals	135.88	469.55	605.43
FAM	Fabricated metals and equipment	1041.34	0.00	1041.34
OTH	Other manufacturing	8.95	0.00	8.95
EDT	Electricity distribution & transmission	0.00	0.00	0.00
GAW	Gas and water reticulation	0.00	50.04	50.04
CON	Construction	2142.45	0.00	2142.45
TRA	Trade, restaurants & accommodation	2126.90	0.00	2126.90
TNS	Transport	2269.59	0.00	2269.59
COM	Communications	359.47	0.00	359.47
FIR	Finance and insurance	776.09	0.00	776.09
OWN	Owner occupied dwellings	0.00	0.00	0.00
PRI	Private services	1050.94	0.00	1050.94
GOV	Government services	1230.97	0.00	1230.97
EGR	Electricity generation – renewables	0.00	373.71	373.71
EGF	Electricity generation – fossil fuels	5391.78	0.00	5391.78
PRICON	Private household consumption	3681.94	0.00	3681.94
TOTAL	Total	29285.31	2860.48	32145.79

Appendix C: Industry CO_2 Emissions

		BAU	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
		Gg	Percentage change on 'Business as Usual' Scenario							
SHB	Sheep and beef farming	191.00	-0.39	-0.13	-0.62	0.95	-0.28	0.05	-0.14	-0.22
DAI	Dairy farming	205.42	-0.44	-0.14	-0.72	0.81	-0.35	0.00	-0.22	-0.26
OAG	Other agriculture	230.92	-0.47	-0.16	-0.73	0.95	-0.29	0.02	-0.14	-0.30
FSH	Fishing and hunting	411.90	-3.26	-1.12	-5.24	-1.94	-3.15	-2.84	-3.02	-3.10
FOR	Forestry and logging	161.13	-0.50	-0.16	-0.81	1.01	-0.34	-0.25	-0.28	-0.43
COA	Coal mining	84.18	-7.00	-2.64	-10.45	3.04	-6.81	-6.55	-6.66	-6.85
GAS	Gas and oil exploration & production	288.92	-0.91	-0.26	-1.64	1.29	-0.69	-0.30	-0.44	-0.73
MIN	Other mining	338.96	-5.07	-1.79	-8.02	-1.57	-4.87	-4.67	-4.71	-4.97
FBT	Food processing	2384.45	-6.44	-2.38	-9.78	-5.21	-6.36	-5.95	-6.18	-6.25
TAL	Textiles and apparel	330.88	-10.24	-4.11	-14.65	-9.05	-10.12	-9.81	-9.93	-10.10
WOD	Wood processing	243.78	-0.62	-0.21	-1.01	0.27	-0.46	-0.35	-0.31	-0.57
PAP	Paper and printing	541.57	-0.68	-0.23	-1.07	-0.22	-0.52	-0.17	-0.29	-0.52
PET	Petroleum	3149.79	-1.59	-0.53	-2.61	4.27	-1.42	-1.16	-1.27	-1.45
CHE	Other chemicals	313.95	-0.26	-0.08	-0.42	0.04	-0.11	0.20	0.09	-0.11
CEM	Cement	1361.30	-6.57	-2.46	-9.87	-5.88	-6.40	-6.49	-6.40	-6.58
CER	Ceramics	274.21	-2.28	-0.82	-3.55	-1.06	-2.12	-2.13	-2.06	-2.27
FES	Iron and steel	2323.96	-4.36	-1.48	-7.07	-4.22	-4.06	-3.87	-3.85	-4.25
ALO	Aluminium and other metals	610.47	-1.41	-0.47	-2.31	-1.37	-1.16	-0.95	-0.98	-1.30
FAM	Fabricated metals and equipment	1049.12	-2.51	-0.97	-3.73	-1.59	-2.25	-2.23	-2.15	-2.48
OTH	Other manufacturing	9.00	0.00	0.00	0.00	-0.11	0.11	0.33	0.33	0.11
EDT	Electricity distribution & transmission	0.00								
GAW	Gas and water reticulation	50.22	-0.60	-0.20	-0.96	-0.20	-0.48	-0.22	-0.32	-0.48
CON	Construction	2157.37	-1.83	-0.63	-2.96	0.13	-1.66	-1.86	-1.70	-1.89
TRA	Trade, restaurants & accommodation	2139.62	-1.46	-0.50	-2.35	0.38	-1.34	-0.99	-1.12	-1.31
TNS	Transport	2287.39	-1.17	-0.39	-1.91	1.57	-1.03	-0.76	-0.86	-1.04
COM	Communications	361.65	-1.55	-0.52	-2.53	0.60	-1.44	-1.11	-1.24	-1.42
FIR	Finance and insurance	780.78	-2.24	-0.78	-3.58	0.04	-2.13	-1.96	-2.01	-2.16
OWN	Owner occupied dwellings	0.00								
PRI	Private services	1055.53	-7.68	-3.73	-10.05	-5.46	-7.63	-7.19	-7.39	-7.49
GOV	Government services	1230.84	-4.49	-1.76	-6.53	-3.95	-4.47	-4.47	-4.49	-4.48
EGR	Electricity generation – renewables	374.45	-0.41	-0.12	-0.70	0.02	-0.30	0.31	0.06	-0.17
EGF	Electricity generation – fossil fuels	5408.17	-4.97	-1.83	-7.55	-3.99	-4.86	-4.41	-4.64	-4.77
PRICON	Private household consumption	3705.48	-1.15	-0.39	-1.88	2.88	-1.12	-0.66	-0.91	-0.93
TOTAL	Total	34056.41	-3.20	-1.19	-4.89	-1.15	-3.06	-2.79	-2.90	-3.06

Appendix D: Industry Gross Output

		BAU	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
		$m (1994/95)	Percentage change on 'Business as Usual' Scenario							
SHB	Sheep and beef farming	4710.1	-0.03	0.00	-0.04	0.11	0.10	0.46	0.26	0.15
DAI	Dairy farming	3626.7	-0.05	-0.01	-0.07	0.11	0.06	0.47	0.23	0.15
OAG	Other agriculture	4377.0	0.08	0.04	0.13	0.22	0.27	0.60	0.43	0.25
FSH	Fishing and hunting	813.9	-0.12	-0.03	-0.19	0.04	0.01	0.36	0.17	0.06
FOR	Forestry and logging	4131.0	0.08	0.03	0.13	0.08	0.26	0.40	0.37	0.16
COA	Coal mining	262.0	-7.00	-2.64	-10.46	3.04	-6.82	-6.55	-6.67	-6.86
GAS	Gas and oil exploration & production	991.9	-0.91	-0.26	-1.64	1.30	-0.69	-0.30	-0.43	-0.72
MIN	Other mining	650.8	-1.51	-0.51	-2.44	-0.24	-1.28	-1.09	-1.13	-1.40
FBT	Food processing	21127.4	-0.08	-0.02	-0.12	0.07	0.03	0.44	0.19	0.13
TAL	Textiles and apparel	4400.0	-0.02	0.00	-0.02	0.11	0.13	0.45	0.32	0.13
WOD	Wood processing	6068.6	0.02	0.01	0.04	0.05	0.21	0.30	0.33	0.07
PAP	Paper and printing	6822.8	-0.06	-0.01	-0.09	-0.02	0.13	0.43	0.31	0.10
PET	Petroleum	4081.4	-1.59	-0.53	-2.61	4.27	-1.42	-1.16	-1.27	-1.45
CHE	Other chemicals	3844.6	-0.16	-0.05	-0.26	0.02	0.01	0.30	0.18	-0.02
CEM	Cement	316.9	-0.51	-0.17	-0.81	-0.43	-0.33	-0.41	-0.32	-0.52
CER	Ceramics	1804.8	-0.33	-0.11	-0.53	-0.23	-0.15	-0.17	-0.11	-0.32
FES	Iron and steel	1169.1	-4.36	-1.48	-7.07	-4.22	-4.06	-3.87	-3.85	-4.25
ALO	Aluminium and other metals	2235.2	-1.28	-0.43	-2.10	-1.36	-1.03	-0.83	-0.85	-1.17
FAM	Fabricated metals and equipment	14032.1	-0.21	-0.07	-0.34	-0.20	0.08	0.07	0.15	-0.18
OTH	Other manufacturing	590.9	0.06	0.03	0.10	-0.04	0.26	0.49	0.40	0.19
EDT	Electricity distribution & transmission	3271.8	-1.07	-0.35	-1.75	-0.61	-0.96	-0.39	-0.64	-0.84
GAW	Gas and water reticulation	1049.4	-0.58	-0.19	-0.94	-0.20	-0.47	-0.20	-0.30	-0.46
CON	Construction	18619.6	-0.20	-0.07	-0.32	-0.13	-0.01	-0.22	-0.07	-0.26
TRA	Trade, restaurants & accommodation	34070.3	-0.10	-0.03	-0.16	0.19	0.05	0.36	0.22	0.05
TNS	Transport	13488.7	-0.17	-0.05	-0.28	0.36	-0.01	0.25	0.15	-0.04
COM	Communications	5447.6	-0.08	-0.02	-0.13	0.01	0.05	0.37	0.24	0.05
FIR	Finance and insurance	28373.9	-0.06	-0.02	-0.09	0.07	0.08	0.25	0.19	0.03
OWN	Owner occupied dwellings	10930.2	0.16	0.05	0.28	0.00	0.25	-0.12	0.16	0.01
PRI	Private services	11710.6	-0.07	-0.02	-0.10	0.11	0.01	0.43	0.22	0.13
GOV	Government services	19358.9	-0.02	-0.01	-0.03	0.01	-0.01	0.02	0.01	0.00
EGR	Electricity generation – renewables	1395.9	-0.41	-0.12	-0.70	0.02	-0.30	0.31	0.06	-0.17
EGF	Electricity generation – fossil fuels	623.2	-2.54	-0.87	-4.09	-2.02	-2.43	-1.96	-2.20	-2.34
TOTAL	Total	234397.1	-0.18	-0.06	-0.28	0.09	-0.03	0.15	0.08	-0.08

Appendix E: Market Shares Held by Domestic Firms for Selected Industries*

		BAU	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
		sales by domestic firms as a percentage of total sales								
GAS	Gas and oil exploration & production	54.4	54.6	54.5	54.6	53.6	54.6	54.7	54.6	54.6
MIN	Other mining	75.9	75.6	75.8	75.5	75.7	75.7	75.7	75.7	75.6
FBT	Food processing	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8	89.8
TAL	Textiles and apparel	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4
WOD	Wood processing	92.2	92.2	92.2	92.2	92.2	92.2	92.2	92.2	92.2
PAP	Paper and printing	80.5	80.5	80.5	80.5	80.4	80.5	80.6	80.5	80.5
PET	Petroleum	52.8	52.5	52.7	52.3	54.4	52.5	52.5	52.5	52.5
CHE	Other chemicals	59.0	59.0	59.0	59.0	59.0	59.0	59.0	59.0	59.0
CER	Ceramics	78.1	78.0	78.0	77.9	78.0	78.0	78.0	78.0	78.0
FES	Iron and steel	62.2	60.8	61.7	59.9	60.8	60.8	60.9	60.9	60.8
ALO	Aluminium and other metals	78.0	77.9	78.0	77.8	77.9	77.9	77.9	77.9	77.9
FAM	Fabricated metals and equipment	48.1	48.1	48.1	48.0	48.0	48.1	48.1	48.1	48.1
OTH	Other manufacturing	51.4	51.4	51.4	51.5	51.4	51.5	51.4	51.5	51.4
TRA	Trade, restaurants & accommodation	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3	89.3
TNS	Transport	86.8	86.8	86.8	86.8	86.9	86.8	86.8	86.9	86.8
TOTAL	Total	84.7	84.6	84.7	84.6	84.7	84.7	84.7	84.7	84.7

* Many industries face no significant competition from imports for market share.

Appendix F: Exports by Commodity

	BAU	Run 1	Run 2	Run 3	Run 4	Run 5	Run 6	Run 7	Run 8
	$m (1994/95)	Percentage change on 'Business as Usual' Scenario							
Dairy	5187.7	-0.04	-0.01	-0.06	0.01	0.02	0.09	0.07	-0.01
Meat	3064.7	-0.04	-0.01	-0.07	0.00	0.02	0.08	0.07	-0.01
Wool	986.4	0.00	0.00	0.00	0.07	0.06	0.11	0.09	0.03
Horticulture	2032.5	0.16	0.06	0.27	0.41	0.41	0.63	0.56	0.29
Fish	1204.8	-0.26	-0.08	-0.41	-0.11	-0.07	0.11	0.06	-0.15
Food & beverages	2956.0	0.00	0.00	0.00	0.08	0.20	0.39	0.33	0.11
Textiles & apparel	1816.0	0.09	0.04	0.17	0.00	0.29	0.47	0.41	0.20
Wood & logs	4068.0	0.12	0.05	0.21	0.12	0.29	0.47	0.42	0.22
Paper products	1289.4	0.06	0.03	0.11	-0.26	0.30	0.53	0.46	0.19
Coal	86.4	-0.87	-0.28	-1.44	26.27	-0.58	-0.38	-0.46	-0.73
Mining	61.1	-1.01	-0.33	-1.64	-0.54	-0.80	-0.62	-0.67	-0.90
Chemicals	2218.7	0.11	0.04	0.18	-0.10	0.31	0.48	0.43	0.21
Ceramics	56.3	-4.14	-1.46	-6.57	-4.01	-3.94	-3.78	-3.84	-4.03
Iron & steel	479.2	-5.91	-2.02	-9.55	-5.77	-5.71	-5.40	-5.46	-5.77
Aluminium	1290.6	-1.26	-0.42	-2.07	-1.38	-1.07	-0.84	-0.90	-1.15
Machinery	3667.4	-0.14	-0.04	-0.23	-0.36	0.02	0.17	0.13	-0.06
Other mfg.	425.0	0.10	0.04	0.17	-0.13	0.29	0.45	0.40	0.20
Tourism	8260.6	-0.22	-0.07	-0.36	0.62	-0.05	0.11	0.06	-0.13
Transport	1180.2	-0.11	-0.03	-0.18	0.48	0.09	0.28	0.22	0.00
Other services	2379.5	0.16	0.06	0.27	-0.06	0.31	0.53	0.49	0.26
Energy & methanol	823.7	-1.81	-0.60	-2.99	-1.70	-1.60	-1.39	-1.45	-1.69
Total	43534.1	-0.18	-0.05	-0.28	0.03	-0.02	0.14	0.09	-0.09