An Economic Assessment of a Carbon Dividend in New Zealand

for Citizens' Climate Lobby New Zealand

March 2021

Infometrics

Economics put simply

Authorship

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1. Introduction & Summary

Infometrics has been requested by Citizens' Climate Lobby New Zealand to undertake an economic assessment of a proposed Carbon Dividend. Broadly speaking the proposal is to recycle the revenue from a price on GHG emissions (whether via a tax or emissions trading scheme) back to households in the form of a uniform divided per adult and a lower amount per child.

The premise underlying the proposal is that high carbon prices such as those that emerge from some of the modelling by the New Zealand Climate Change Commission are unlikely to be acceptable to the community unless it can be demonstrated that most people will not be worse off.

The results of the modelling reveal that by 2050 New Zealand's CO_2 emissions decline by 25% relative to a 'Reference' scenario. Real private consumption increases by 1.9% and each adult receives a carbon dividend of more than $1000 per year. In addition a disproportionate share of the benefits goes to lower income households.

2. Methodology

We use the ESSAM general equilibrium model of the New Zealand economy to investigate the national costs and benefits of applying a high price on greenhouse gas (GHG) emissions and recycling the resulting revenue back to households in the form of a per capita dividend. Details of the proposed scheme are presented in the next section.

ESSAM Model

The ESSAM (Energy Substitution, Social Accounting Matrix) model is a multi-industry computable general equilibrium (CGE) model of the New Zealand economy. An outline is provided in Appendix A.

As with any model, CGE models can only approximate the highly complex real economy. Therefore the results can only ever be indicative. The interpretation of CGE results should centre on their direction (up or down) and broad magnitude (small, medium or large), rather than on the precise point estimates that the model produces. Essentially we are modelling scenarios: such modelling "does not predict what will happen in the future. Rather, it is an assessment of what could happen in the future, given the structure of the models and input assumptions."[1]

Reference Scenario

The model is used to produce a Reference scenario for 2050. It is similar to the CPR scenario in the Climate Change Commission's report[2], but with a slightly higher carbon price to acknowledge the likelihood that the price will rise from its current $35 or so per tonne of CO_2e. Nevertheless the scenario is a theoretical construct of what the economy could look like at a future point in time with the continuation not only of existing policies, but also of other trends such as falling prices of electric vehicles, and without any large exogenous economic shocks. The function of the Reference scenario is to act as a point of comparison against which other scenarios can be compared.

Two key assumptions for the Reference scenario and all other scenarios are:

1. New Zealand population is projected to be 6.2 million in 2049/50. (StatsNZ 50th percentile).
2. Real oil price in 2049/50: US$80/bbl.

More detail on the assumptions is given in the section on scenario specification.

Model Closure

The following model closure rules are adopted for the alternative scenarios, consistent with generally accepted modelling practice:

1. The current account balance is fixed as a percentage of GDP. This means for example that if New Zealand needs to purchase international emissions units to

[1] Australian Treasury. (2008). *Australia's low pollution future: the economics of climate change mitigation*. Online at http://www.treasury.gov.au/lowpollutionfuture/report/default.asp

[2] https://www.climatecommission.govt.nz/get-involved/our-advice-and-evidence/

meet an emissions responsibility target, that liability cannot be met simply by borrowing more from offshore with indefinitely deferred repayment.

2. The post-tax rate of return on investment is unchanged between scenarios. This acknowledges that New Zealand is part of the international capital market and ensures consistency with the preceding closure rule.

3. Any change in the demand for labour is reflected in changes in wage rates, not changes in employment. This prevents the long run level of total employment being driven more by emissions policy than by the forces of labour supply and demand, which we consider unlikely.

4. The fiscal balance is fixed across scenarios. This means for example that if the government needs to purchase overseas emission units it must ensure that it has matching income. If it earns insufficient income from the sale of domestic emission units (because of free allocation for example) it would have to adjust tax rates. Generally net household effective income tax rates are the default equilibrating mechanism, although changing government expenditure or other tax rates are alternative options that may also be used.

   In the Carbon Dividend scenario the equilibrating mechanism is the value of the dividend.

3. Carbon Dividend Scenario

Aligning the modelling to that published by the Commission has proved tricky, partly because the scenarios in the report are produced by the partial equilibrium ENZ model but, apart from the Current Policy Reference (CPR) scenario, have no corresponding scenario in the C-PLAN general equilibrium modelling – and even there are differences.

Emissions in our Reference scenario are somewhat lower than in the Commission's CPR scenario owing to our assumption of an $80 price on long-lived gases rather than the $35 used by the Commission, which seems particularly low for 2050, even for Reference scenario.

Our second scenario is close to the Commission's TP1 and TP2 scenarios produced by the C-PLAN model.

Input Assumptions

In the Reference scenario for 2050 there is a modest carbon price of $80/tonne CO_2e for long lived gases and no price on biogenic methane (CH_4). Although this scenario is not intended to exactly replicate the Commission's CPR scenario, it does include a number of identical exogenously stipulated features from the ENZ model, the most significant of which are:

- Progressive penetration of electric vehicles (without any explicit policy changes).
- Closure of methanol production and aluminium smelting.
- No growth in steel production.
- No domestic oil refining.
- More electricity generation from renewable sources, but some gas for dry years or peak demand.
- Reduction or limited increase in cattle and sheep numbers.

A second scenario, the Carbon Dividend scenario, is designed to meet the government's net zero target for long-lived gases (CO_2 and N_2O) by 2050, by whatever carbon price is required. This is denoted as the ETS1 price. A lower price is assumed for biogenic methane, also with the aim of meeting the target of 24-47% below 2017 by 2050. This is denoted as the ETS2 price.

The other key difference between the two scenarios is that in the Reference scenario revenue from the ETS is allocated to general government consumption (so not including transfers), after payment for any international emission units needed to meet New Zealand's Nationally Determined Contributions. In contrast under the Carbon Dividend scenario most of the ETS revenue is available to allocate to households as a carbon dividend.

The key input assumptions are summarised in Table 1. In the Commission's modelling with C-PLAN, in scenarios T1 and T2, the price under ETS1 is around $337, while the ETS2 price is around $53. All carbon prices are expressed in 2020 dollars.

Table 1: Input Assumptions for 2050

	Reference scenario	Carbon Dividend scenario
ETS1 price	$80	$400
ETS2 price	$0	$50
International price	$250	$250
ETS recycling	mostly to govt spending & purchase of international units	mostly to household dividend
Net forestry	-19.5Mt	-19.5Mt

Output

The main results are summarised in Table 2. They demonstrate that a high price on long-lived gases plus revenue recycling to households, does not entail a macroeconomic cost and may indeed produce a macroeconomic benefit. Although GDP declines slightly relative to Reference, this is more than offset by the increase in real gross national disposable income. The latter is a better measure of economic benefit than GDP as it allows for changes in the terms of trade (a higher price for a tonne of milksolids means we can buy more imports) and for changes in payments for overseas emission units.[3]

With no need to purchase international units, more of the nation's income is available for domestic consumption which increases by 1.9% over the reference scenario. In other words, the average household obtains 1.9% more goods and services.

Table 2: Summary of Model Output

	Carbon Dividend v Reference	Notes
Private Consumption	1.9%	
Exports	-4.5%	less required to pay for overseas units
Imports	-1.0%	
GDP	-0.2%	
RGNDI	0.8%	
Total CO_2e	-25.1%	43.1 Mt v 57.6 Mt in Reference scenario
Biogenic CH_4	-9.3%	24.0 Mt v 26.5 Mt
Long-lived CO_2e	-38.6%	19.1 Mt v 31.1 Mt

Two caveats should be noted:

1. It is possible that aligning the domestic carbon price with the international carbon price would generate an even more favourable macroeconomic picture, but our intention with the Carbon Dividend scenario is to be consistent with the Commission's other scenarios – namely to achieve net zero in long-lived gases without purchasing international units.

2. The macroeconomic effects might also be more favourable if the higher carbon price leads to additional technological advances such as a methane vaccine or cement production without CO_2 emissions. No such innovations have been assumed so as to maintain a cleaner comparison with the Reference case.

[3] Technically emissions units may be treated as a stock (asset) rather than a flow, but this does not change the essence of the argument, given the closure assumptions.

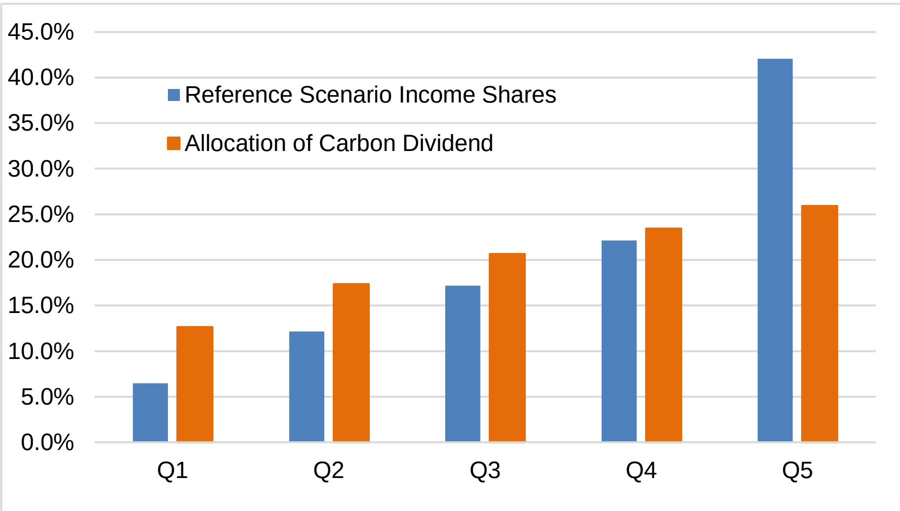
Carbon Dividend

In the Carbon Dividend scenario the revenue available for a dividend in 2050 is $6200m (in constant 2020 dollars) . Allocation could be as follows:

- The projected population in 2050 (Stats NZ; 50th percentile) is 6.20m, of which,
    - Under 18 years of age: 1.15m
    - 18 years and over: 5.05m
- So assuming that those under 18 get 50% of the adult dividend, the adult dividend is $1100 per annum. (An alternative option is pay 50% to dependent children, but a simple age boundary is operationally more straightforward).
- The implied average dividend per household is about $2400, allowing for people who do not live in private households, for example those in residential care homes.

Figure 1 illustrates the allocation of the dividend by household income quintile compared to the quintile shares of total income in the Reference scenario.

Figure 1: Incidence of Carbon Dividend and Reference Scenario Income by Household Income Quintile



Bearing in mind that the number of people in each quintile increases through the quintiles, the Carbon Dividend shows a marked distributional effect. For example the lowest quintile (Q1) has 6.4% of all household income, but 12.7% of the dividend. In contrast the top quintile (Q5) has 42.1% of all household income, but only 25.9% of the dividend.

A carbon price of $400/tonne would raise the price of petrol by about 97c/litre. From the model's results it is estimated that Q1 households would spend about $94m (excluding tax) on petrol and diesel (in 2050) in the Carbon Dividend scenario. However, this is more than absorbed by the approximately $780m that Q1 households would receive from the Carbon Dividend.

Comment

The core message from these results is that increasing the carbon price and recycling the revenue through a Carbon Dividend produces a small increase in national income and an associated improvement in economic wellbeing. The social/political message (which cannot be demonstrated with a general equilibrium model) is that to secure community buy-in for a high carbon price and lower emissions, people have to see that it is not about making them poorer and that the impacts are equitable.

The point of a carbon price is to change relative prices in favour of low carbon goods and services. This should not make consumers worse off (or at least minimise any loss) and one way to ensure that is via a lump sum dividend. An additional benefit is that it assists those with lower incomes, meeting the government's aim of a 'just transition'.

Furthermore, a price on carbon should not be an excuse to increase government spending. If there is a case for that, other funding mechanisms should be analysed so that the mechanism of a carbon price is not further complicated by political taxation considerations.

Appendix A: ESSAM Model

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

- Analysis of the New Zealand Emissions Trading Scheme and other options to reduce greenhouse gas emissions
- Changes in import tariffs
- Public investment in new technology
- Funding regimes for roading and wider economic benefits
- Release of genetically modified organisms

Some of the model's features are:

- 55 industry groups, as detailed in the table below.
- Substitution between inputs into production - labour, capital, materials, energy.
- Four energy types: coal, oil, gas and electricity, between which substitution is also allowed.
- Substitution between goods and services used by households.
- Social accounting matrix (SAM) for tracking financial flows between households, government, business and the rest of the world.

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.

Model Structure

Production Functions

These equations determine how much output can be produced with given amounts of inputs. For most industries a two-level standard translog specification is used which distinguishes four factors of production – capital, labour, and materials and energy, with energy split into coal, oil, natural gas and electricity.

Intermediate Demand

A composite commodity is defined which is made up of imperfectly substitutable domestic and imported components - where relevant. The share of each of these components is determined by the elasticity of substitution between them and by relative prices.

Price Determination

The price of industry output is determined by the cost of factor inputs (labour and capital), domestic and imported intermediate inputs, and tax payments (including tariffs). World prices are not affected by New Zealand purchases or sales abroad.

Consumption Expenditure

This is divided into Government Consumption and Private Consumption. For the latter eight household commodity categories are identified, and spending on these is modelled using price and income elasticities in an AIDS framework. An industry by commodity conversion matrix translates the demand for commodities into industry output requirements and also allows import-domestic substitution.

Government Consumption is usually either a fixed proportion of GDP or is set exogenously. Where the budget balance is exogenous, either tax rates or transfer payments are assumed to be endogenous.

Stocks

The industry composition of stock change is set at the base year mix, although variation is permitted in the import-domestic composition. Total stock change is exogenously set as a proportion of GDP, domestic absorption or some similar macroeconomic aggregate.

Investment

Industry investment is related to the rate of capital accumulation over the model's projection period as revealed by demand for capital in the horizon year. Allowance is made for depreciation in a putty-clay model so that capital cannot be reallocated from one industry to another faster than the rate of depreciation in the source industry. Rental rates or the service price of capital (analogous to wage rates for labour) also affect capital formation. Investment by industry of demand is converted into investment by industry of supply using a capital input- output table. Again, import-domestic substitution is possible between sources of supply.

Exports

These are determined from overseas export demand functions in relation to world prices and domestic prices inclusive of possible export subsidies, adjusted by the exchange rate. It is also possible to set export quantities exogenously.

Supply-Demand Identities

Supply-demand balances are required to clear all product markets. Domestic output must equate to the demand stemming from consumption, investment, stocks, exports and intermediate requirements.

Balance of Payments

Receipts from exports plus net capital inflows (or borrowing) must be equal to payments for imports; each item being measured in domestic currency net of subsidies or tariffs.

Factor Market Balance

In cases where total employment of a factor is exogenous, factor price relativities (for wages and rental rates) are usually fixed so that all factor prices adjust equi-proportionally to achieve the set target.

Income-Expenditure Identity

Total expenditure on domestically consumed final demand must be equal to the income generated by labour, capital, taxation, tariffs, and net capital inflows. Similarly, income and expenditure flows must balance between the five sectors identified in the model – business, household, government, foreign and capital.

Industry Classification

The 55 industries identified in the standard ESSAM model are defined on the following page. Industries definitions are according to Australian and New Zealand Standard Industrial Classification (ANZSIC06).

Input-Output Table

The model is based on Statistics New Zealand's latest input-output table which relates to 2012/13.

Model Industries

	Abbrev	Description
1	HFRG	Horticulture and fruit growing
2	SBLC	Sheep, beef, livestock and cropping
3	DAIF	Dairy and cattle farming
4	OTHF	Other farming
5	SAHF	Services to agriculture, hunting and trapping
6	FOLO	Forestry and logging
7	FISH	Fishing
8	COAL	Coal mining
9	OIGA	Oil and gas extraction, production & distribution
10	OMIN	Other Mining and quarrying
11	MEAT	Meat manufacturing
12	DAIR	Dairy manufacturing
13	OFOD	Other food manufacturing
14	BEVT	Beverage, malt and tobacco manufacturing
15	TCFL	Textiles and apparel manufacturing
16	WOOD	Wood product manufacturing
17	PAPR	Paper and paper product manufacturing
18	PRNT	Printing, publishing and recorded media
19	PETR	Petroleum refining, product manufacturing
20	CHEM	Other industrial chemical manufacturing
21	FERT	Fertiliser
22	RBPL	Rubber, plastic and other chemical product manufacturing
23	NMMP	Non-metallic mineral product manufacturing
24	BASM	Basic metal manufacturing
25	FABM	Structural, sheet and fabricated metal product manufacturing
26	MAEQ	Machinery and other equipment manufacturing
27	OMFG	Furniture and other manufacturing
28	EGEN	Electricity generation
29	EDIS	Electricity transmission and distribution
30	WATS	Water supply
31	WAST	Sewerage, drainage and waste disposal services
32	CONS	Construction
33	TRDE	Wholesale and retail trade
34	ACCR	Accommodation, restaurants and bars
35	ROAD	Road transport
36	RAIL	Rail transport
37	WATR	Water transport
38	AIRS	Air Transport
39	TRNS	Transport services
40	PUBI	Publication and broadcasting
41	COMM	Communication services
42	FIIN	Finance and insurance
43	HIRE	Hiring and rental services
44	REES	Real estate services
45	OWND	Ownership of owner-occupied dwellings
46	SPBS	Scientific research and computer services
47	OBUS	Other business services
48	GOVC	Central government administration and defence
49	GOVL	Local government administration
50	SCHL	Pre-school, primary and secondary education
51	OEDU	Other education
52	MEDC	Medical and care services
53	CULT	Cultural and recreational services
54	REPM	Repairs and maintenance
55	PERS	Personal services

Appendix B: Carbon Dividend

The proposal is that the Carbon Dividend is allocated uniformly to every adult aged 18 years and over, with those under 18 receiving 50% of the adult amount. The disaggregation of the household sector in the model is limited to income quintiles, so it is necessary to estimate how the dividend allocation rule maps to household income quintiles.

Table B1 is estimated using data from three sources; the 2018 Census, the 2016 Household Economic Survey and a customised table from the 2017 Household Net Worth Statistics, all from Statistics New Zealand. The projected age distribution of the population in 2050 is allocated to household income quintiles according to the 2017-18 age-by-income quintile distribution.

Note that about 12% of the population is not resident in private households.

Given the aging of the population and smaller families, there will likely be smaller households by 2050, but any effect on the dividend shares is not readily apparent.

Table B1: Allocation of the Carbon Dividend

	Q1	Q2	Q3	Q4	Q5	All
No. people in households in 2018						
No. Children	90	143	218	265	309	1025
No. Adults	434	585	673	755	827	3275
Total number	524	729	891	1020	1136	4300
Children weighted at 50% in 2018						
Total number	479	657	782	888	982	3787
Shares	12.7%	17.3%	20.6%	23.4%	25.9%	100.0%
Reference scenario						
Income shares	6.4%	12.1%	17.2%	22.1%	42.1%	100.0%