The Economic Effects of a Price on International Transport Emissions

for Ministry for Primary Industries

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Contents

1. Summary

Infometrics has been requested by the Ministry for Primary Industries to analyse the wider economic effects of a price on the carbon emissions of international aviation and maritime transport.

Approach

We use a general equilibrium model of the New Zealand economy for this purpose and we simulate a price on emissions by raising the cost of transport (for goods and people) in proportion to both distance travelled and average emissions intensity per kilometre, paid on incoming flights and sailings. This is a departure from the usual idea of taxing the carbon content of bunker fuels.

Main findings

The incremental effect of a NZ$50/tonne price on CO_2 emissions, relative to a situation where the same carbon price is already levied on countries' domestic emissions, is a reduction in New Zealand's real gross national disposable income (RGNDI) of 0.3%. The impact is attributable almost entirely to aviation. This is because maritime transport is far less carbon intensive per tonne kilometre than aviation and foreign tourism is barely affected by the cost of maritime fuel oil. Even a doubling of carbon emissions from sea transport has almost no impact on the results.

The negative effect on RGNDI is caused by both the decline in New Zealand's competitiveness (consequent to any increase in costs that has a distance component) and the assumption that all revenue from the carbon charge is remitted to an offshore institution. If this assumption is relaxed such that New Zealand retains all of the revenue from an emissions charge on incoming flights and sailings, the relative decline in RGNDI is only 0.1% instead of 0.3%.

In a scenario where only New Zealand puts a charge on international transport emissions from incoming flights and sailings – an extreme case of limited participation by the rest of the world, the macroeconomic impacts are not very different to those under full international participation. Although the decline in competitiveness is greater, this is offset by not having to pay for emissions associated with exports.

Caveats

Apart from the inherent limitations of the model such as not explicitly incorporating the rest of the world, the modelling required a number of assumptions about, and estimates of freight margins, market shares of domestic and foreign carriers, carrier operating costs, carbon intensity and total emissions, future fuel prices, and so on. While all such assumptions are subject to error we are reasonably confident that none are so wrong as to completely invalidate the modelling results. Sensitivity testing is undertaken on the most uncertain assumptions.

Nevertheless we urge caution. The results should be seen as indicative of relative changes under various hypothetical scenarios, not as precise forecasts.

2. Methodology

Introduction

There are two ways in which international transport could be brought into an emissions pricing regime:

1. Attribute all international air and maritime transport emissions to individual countries and include them in countries' inventories and international emissions obligations.
2. Introduce a separate sector agreements with a carbon charge or other market based instrument on all airlines and shipping lines.

For each of these two regimes a carbon charge could be collected in a number of ways (points of obligation), based on:

1. Bunkering fuel purchases.
2. Passenger kilometres or tonne kilometres.
3. Nationality of airline/shipping line or nationality of passengers.

Here we examine the second regime (separate sector agreement) and the second method of collection. In particular it is assumed that incoming flights and sailings will have their emissions priced (taxed) in relation to the distance travelled, as this pre-empts the potential problem that occurs if bunker fuels are taxed, whereby shipping lines, and airlines to a lesser extent, could change where they refuel.

In practice it is not easy to determine the beginning and end of a flight or sailing. Furthermore even if an incoming flight did originate in say London, it would be unfair to tax all incoming tourists for emissions over the full distance to Auckland if some of them joined the flight in Singapore.

Approach to Simulating an Emissions Price

To simulate a price on emissions from international transport we adopt the following procedure:

1. For imports of goods we assume that the difference between Value for Duty (VFD) and value inclusive of Cost, Insurance and Freight (CIF) represents a reasonable estimate of the cost of transporting the goods to New Zealand. The difference picks up the effect of both distance and mode.
2. These differences are assumed to apply – commodity by commodity – to Free on Board (FOB) exports.
3. However the margin is adjusted for differences in distance travelled, as summarised in Table 1, which is drawn from 2015 data. It will be seen that on average imports travel over a slightly longer distance than exports. Given the closeness (±5%) and the fact that we are projecting to 2028, we avoid spurious accuracy and simply assume that average export distance is the same as average import distance.

Table 1: Mean Distances for Trade and Tourism

Category	Distance (km)
Exports of goods weighted by 21 commodity groups and 25 destinations	10600
Foreign tourists visiting New Zealand weighted by 19 destinations	7400
Imports of goods weighted by 27 commodity groups and 25 origin countries	11200
New Zealand tourists traveling abroad weighted by 7 destinations (regions)	6100

Source: SNZ trade data

4. The composition of the transport margin in terms air transport versus sea transport is separately determined for imports and exports, again on a commodity specific basis.

5. The change in the price of transport consequent to a price on emissions is calculated as:

$$P_T=(P_C/P_F)*(FC/R)$$

P_T is the change in the price of transport

P_C is the carbon price expressed in \$/GJ (\$/GJ=\$/ktCO_2*ktCO_2/GJ)

P_F is the price of fuel in \$/gJ

FC is total fuel costs

R is revenue

The above is applied separately for aviation and maritime transport.

Table 2: Impact of Carbon Price on Transport Costs

		Jet Fuel	Heavy/Bunker Fuel Oil
Current price	NZ\$/GJ	18.92	12.80
Price in 2028*	NZ\$/GJ	31.52	21.32
Emissions	kg CO_2/GJ	67.8	73.3
Impact of \$50/t CO_2	% of price	10.8%	17.2%
Current fuel cost as % revenue**		28.2%	11.0%
2028 fuel cost as % revenue		37.9%	16.1%
Change in transport price		4.1%	2.8%

* Assume oil price rises from US\$/50 to US\$/75 and that the exchange rate is NZ\$1=US\$0.70.

** Source: value for aviation is an average over Air New Zealand, Qantas, Virgin, Singapore Airlines and Emirates. Value for maritime is an average over Maersk, Cosco and Hapag-Lloyd.

6. It is assumed that all tourists travel by air, although this is not strictly true given the growing popularity of cruise ships. Hence the 4.1% effect given in Table 2 applies to tourists. With the weight of travel in total tourist expenditure being about 25%, the overall price impact of an emissions charge of \$50/tonne is only 1%.

7. For transport services themselves the 4.1% and 2.8% from Table 2 apply.

8. As the emissions charge is assumed to levied by other countries as well, New Zealand's competitive position will decline. Foreign tourists will have a price incentive to holiday closer to home and overseas purchasers of our exports may likewise opt to source goods from nearer neighbours. Based on a rough assessment of world trade and tourism flows, it is assumed that the transport price impact on competitor countries is half of the impact on New Zealand, across both transport modes.

9. Whether international transport is undertaken by a New Zealand carrier or a foreign carrier is immaterial with regard to who pays the charge. It is not immaterial, however, with regard to use of the revenue from the charge. We assume that the revenue is paid to an international body and that none of it is redistributed back to New Zealand. Thus there is a balance of payments effect insofar as international transport is undertaken by New Zealand companies. For foreign carriers the net effect is zero as the foreign carrier pays the New Zealand government which then remits the funds offshore.

10. From SNZ inter-industry tables we know the export earnings of the air transport and sea transport industries. Together with the data on transport margins from above, it is possible to deduce that New Zealand airlines have about 51% of the air freight transport market and that New Zealand shipping companies account for about 4.5% of the maritime transport market.[1] These proportions are assumed to apply to both exports and imports. The sums involved suggest the following emission liabilities for freight on New Zealand flagged carriers.

	Maritime	Aviation
Percentage of total freight on NZ carriers	4.5%	51%
Exports	$5m	$9m
Imports	$4m	$7m

11. For tourism it is assumed that New Zealand airlines have a 50% market share.[2] As the number of New Zealand tourists travelling abroad is about 76% of the number of foreign visitors to New Zealand (SNZ), and as the distance they travel is about 82% of what foreign tourists travel (Table 1), it is assumed that the remittances offshore on behalf of New Zealand tourists are 63% of remittances on behalf of foreign tourists. The sums involved suggest that New Zealand's liability for aviation emissions relating to passengers will be around $190m pa by 2028.

12. From the above the implied charge per foreign tourist is about $18, and about $15 per New Zealand tourist. A ball-park realism check: A $50/tonne carbon

[1] The former aligns closely to Air New Zealand's cargo revenue. (Air New Zealand Annual Reports). The latter may include goods shipped around New Zealand en route to or from overseas ports.

[2] Calculations in 2010 by the Ministry of Transport using passenger arrival and departure cards showed a distance weighted split of 48.7%/51.3% between New Zealand operators and foreign operators respectively. This is also consistent with what one can discern from inter-industry data.

charge has the same impact on airline fuel costs as a US$15/bbl increase in the oil price. A rule of thumb when oil prices were high, was that the fuel price surcharge was around $1 per person (for a medium to long haul trip) for every $1 increment in the oil price above 'normal'. Thus we would expect the $50 emission charge to raise airfares by about $15-$20 per person.

Context

In order to provide some context for the analysis we assume that a sector agreement would be implemented before 2028 such that international carriers would by then have fully adjusted to the new regime. This means that we can compare the modelling results against other emission mitigation scenarios that were undertaken in 2015 for the Ministry for the Environment.[3] In particular our Reference Scenario is Scenario A2 which has the following features:

- There is a world emissions price that reaches $50/tonne by 2030. Global carbon price paths were supplied by the Ministry for the Environment, derived from international reports.[4]
- New Zealand participates and has an emissions reduction target of 10% below 1990 emissions by 2030.
- The target can be met by domestic emissions abatement or by purchasing emission units from offshore.
- Agricultural non-CO_2 emissions are not priced, but do count towards emissions budgets.
- There is no "one for two" surrender obligation in the New Zealand ETS.
- There is no free allocation of emission units to trade-exposed emissions-intensive industries in the New Zealand ETS
- There is no ($25) price cap in the New Zealand ETS.

General Equilibrium Modelling

The computable general equilibrium (CGE) model used here is outlined in Appendix A and a description of CGE modelling, its strengths and weaknesses is provided in NZIER & Infometrics (2009).[5] It is a widely used tool for assessing the broad economic effects of climate change mitigation policies in New Zealand. As with any model, CGE models can only be an approximation of the highly complex real economy. They are dependent on the database used, the credibility of the assumptions incorporated into the base case and policy scenarios and the 'closure' framework employed (Concept Economics, 2008, p4).[6] Therefore the results can only

[3] Infometrics (2015): Emissions Reduction Options for New Zealand post 2020; A General Equilibrium Analysis, Report to Ministry for the Environment, April 2015.

[4] Ministry for the Environment 2014. Carbon price path scenarios: 2015-2030.

[5] NZIER and Infometrics (2009): Economic Modelling of New Zealand Climate Change Policy. Report to Ministry for the Environment, May 2009. And Macroeconomic impacts of climate change policy. Impact of Assigned Amount Units and International Trading. Report to Ministry for the Environment, July 2009.

[6] Concept Economics. (2008): 'A peer review of the Treasury modelling of the economic impacts of

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" (Australian Treasury). [7]

CGE modelling can usefully be augmented with sector-specific partial equilibrium modelling and other quantitative and qualitative research approaches, particularly in difficult areas such as international transport.

Caveats

A number of model limitations should be noted:

- **Oil-based fuels:** Apart from the broad distinction between jet fuel and fuel oil, the model does not distinguish between finer types of oil-based transport fuels. For example the model assumes it is not possible for maritime transport to switch between heavy fuel oil and marine diesel, although we could exogenously impose such substitution. The difference in carbon content in this instance is about 12%. Similarly airlines cannot change fuel types.
- **Mode substitution:** There is no mode substitution between international air transport and international sea transport. The only transport substitution in the model is between road and rail for domestic freight, and between private and public transport in household consumption.

It is also worth reiterating the key assumptions made above:

- The differences between CIF and VFD import valuations per commodity group provide a reasonable approximation of transport margins, for both imports and exports.
- Fuel costs in 2028 will be about 38% of the price of air transport and 16% of the price of maritime transport.
- Tourists who arrive in New Zealand by sea are ignored.
- Under emissions pricing the costs of transport to and from New Zealand rise by twice as much as the costs of transport between the countries with which we compete for export markets and foreign tourists.
- New Zealand companies account for 51% of international air freight transport to and from New Zealand. For international sea transport the corresponding share is 4.5%.
- For tourists, New Zealand carriers have a 50% market share. Passenger kilometres by New Zealand tourists travelling abroad are about 63% of those by foreign tourists visiting New Zealand.

Some changes in assumptions are explored later.

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reducing emissions'. Report for Australian Senate Select Committee on Fuel and Energy.

[7] Australian Treasury. (2008). *Australia's low pollution future: the economics of climate change mitigation*, p16. Online at http://www.treasury.gov.au/lowpollutionfuture/report/default.asp

3. Scenario Specification

Baseline

There is a Baseline scenario which has no price on any emissions, and all emissions pricing scenario results are expressed relative to that Baseline. The Baseline is not intended to represent 'Business as Usual' which, arguably, is better represented by the Reference Scenario A2 (discussed above). It is, however, straightforward to compare scenarios with each other in any desired combination, but it greatly assists understanding of the model's results if all are expressed relative to a common base.

Model Closure

For a comparative static model such as ESSAM the closure rules follow generally accepted modelling practice.[8]

1. The current account balance is fixed as a percentage of GDP. This means that if New Zealand has to remit funds offshore to pay for its liability in relation to an emissions charge on international transport, that liability cannot be met simply by borrowing more funds 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.
4. The fiscal balance is fixed across scenarios. We assume that net personal income tax rates are the equilibrating mechanism, although changing government expenditure is an alternative option.

Group 1

We begin with a group of three scenarios where an emissions charge is imposed on international transport.

Scenario T1

- Standard global price of $50/tonne of CO_2 by 2030, as in Scenario A2. Other Scenario A2 assumptions given above.
- Same carbon price on emissions from international aviation and international shipping, paid on incoming flights and sailings. New Zealand collects the charge from transport companies that bring imports and people (foreign tourists) to New Zealand.
- Other countries collect the charge from New Zealand carriers at destinations served by them.

[8] NZIER and Infometrics, op cit.

- All revenue from the carbon charge is paid to an offshore institution. New Zealand receives no distributions from this institution.

Scenario T2

- As in Scenario T1, but exempting international aviation.

Scenario T3

- As in Scenario T1, but exempting international maritime transport.

Group 2

The next group of scenarios looks at a higher carbon price and a sensitivity test on the emissions intensity of international shipping.

Scenario T5

- As in Scenario T1, but raising the emissions price on international transport to \$100/tonne CO_2 by 2030.

Note that the general price on emissions remains at \$50/tonne, which means that global emissions reduction is not economically efficient as the value of a unit of carbon saved does not depend on where it is saved. In reality any divergence in carbon prices would incentivise arbitrage.

Scenario T6

- As in Scenario T1, but doubling the emissions intensity of transporting New Zealand's exports by ship.

This recognises the considerable uncertainty about emissions coefficients for shipping due to factors such as the extra energy (and thus emissions) associated with refrigerated transport, the speed at which ships travel, differences in fuel efficiency between ships of the same type, routes taken (visits to multiple ports) and loading factors. Landcare Research (2010) for example, estimates emissions than are almost double those calculated in Section 2.[9]

Group 3

In this group of scenarios one scenario looks at a unilateral approach by New Zealand, and another looks at a situation where New Zealand retains the revenue it collects on emissions from incoming flights and sailings.

Scenario T4

- As in Scenario T1, but with no action on international transport emissions by the rest of the world. Thus outgoing flights and sailings are not taxed at their destinations, but all incoming ones are.

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[9] Landcare Research (2010):*Greenhouse gases embodied in New Zealand's trade*. Report prepared for Ministry of Agriculture and Forestry.

- This has some conceptual similarity to Scenario U1 discussed in Infometrics (2015, op cit) where New Zealand introduces a carbon price, but the rest of the world does not. However in that scenario that carbon price is much higher.

Under a unilateral approach there would be more substitution by tourists between destinations or between deemed origins such that more of their journey is untaxed. For example if New Zealand taxes international travel on a distance basis, but Australia does not, tourists from Europe might travel via Australia on their way to New Zealand. Indeed airlines might set up hubs for this purpose. Estimating the magnitudes of these effects is almost impossible.

In contrast to foreign tourism, there is no effect on the competitiveness of goods exports as emissions associated with their transport are not taxed at their destination.

The cost of imports is affected – the same as in Scenario T1, as is price of travel for New Zealand tourists returning home.

Scenario T1 relates to a regime in which all countries participate. In reality some or many countries would not participate, but the effects of partial participation on New Zealand are impossible to determine without knowing which countries are in and which are out. Even then an assessment would not be easy. Scenario T4 represents the opposite extreme. It is also unrealistic, but it means that the effects on New Zealand of any plausible scenario that has incomplete participation are likely to lie somewhere between those in Scenarios T1 and T4.

For this reason we retain the Scenario T1 assumption that all revenue from an emissions charge is paid to an offshore entity.

Whether Scenario T4 will produce worse effects or better effects than T1 depends on the net effect of a number of competing factors:

1. The balance of payments impact will be more favourable in T4 as New Zealand carriers are not levied in foreign countries.
2. The relative attractiveness of New Zealand to foreign tourists will worsen.
3. But the effect in (2) will be somewhat dampened by tourists having to pay the emissions charge in only one direction.
4. Exporters do not lose competitiveness in Scenario T4, as the carbon charge is only on incoming transport, not on outbound transport.

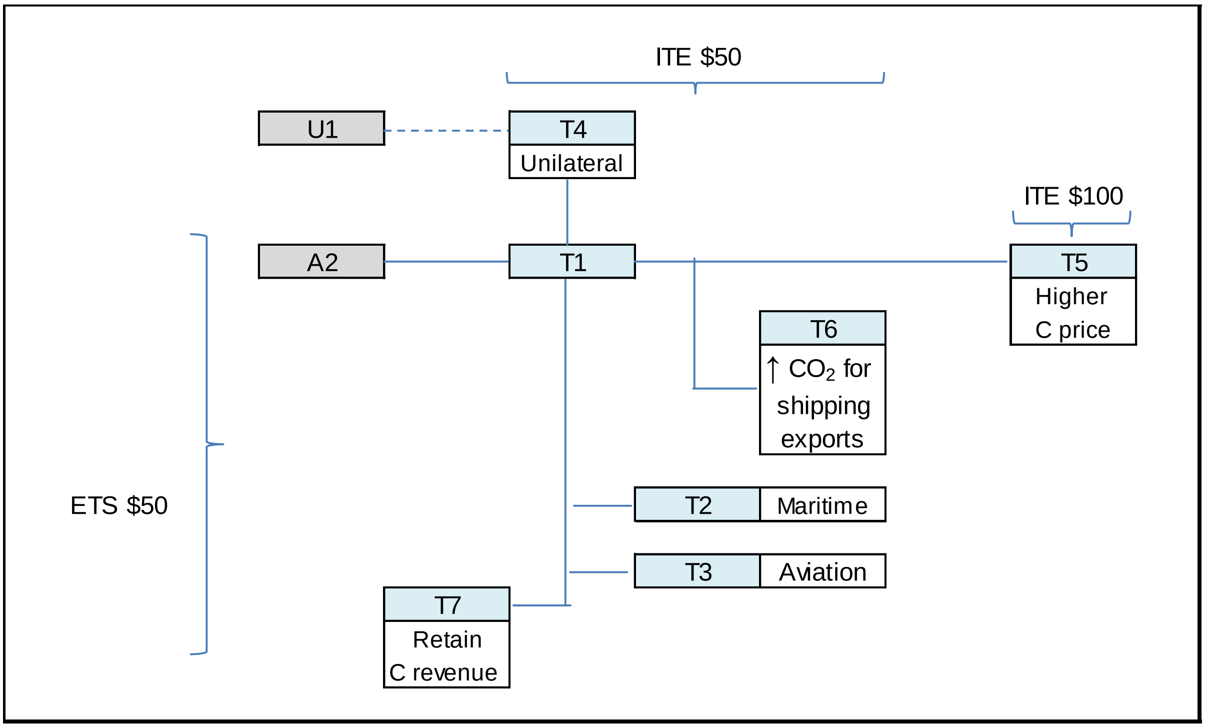
Scenario T7

- As in Scenario T1, but New Zealand retains the revenue from the emissions charge on incoming flights and sailings.

Not only does this mean that the revenue collected from New Zealand carriers on inward trips is retained, New Zealand now also keeps the revenue on foreign carriers that bring people and goods to New Zealand. Given the imbalance in the ratio of New Zealand carriers compared to foreign carriers in shipping, the retention of revenue from foreign carriers has a favourable balance of payments effect. Collecting the revenue based on the 'flag' state of the carrier would mean there is substantively less revenue (refer table page 4)

A schematic of all of the scenarios is shown in Figure 1 below, where ITE is used to denote the carbon price on International Transport Emissions, to distinguish it from that under the New Zealand ETS.

Figure 1: Scenario Outline



4. Results

Group 1

The results for Group 1 are shown in Table 3.

Looking firstly at Scenario T1 in relation to A2, unsurprisingly the addition of what is effectively a 'tax wedge' coupled with the revenue from that tax being sent offshore, has a negative effect on the domestic economy. The decline in RGNDI in Scenario A2 worsens from -1.1% to -1.4% and the decline in private consumptions worsens from -1.4% to -1.7% as households have to pay more for travel and imported goods.

Exports fall by nearly twice as much as in Scenario A2, driven by the decline in international competitiveness commensurate with New Zealand's relative isolation. This is particularly true for tourism exports which fall by nearly four times the decline in Scenario A2, reflecting a high emissions intensity, and transport exports which decline by a similar multiple. These two categories constitute about 15% of exports.

Table 3: Group 1 Scenarios

	A2	T1 Maritime & Aviation	T2 Maritime only	T3 Aviation only
		% Δ on Baseline		
Private consumption	-1.4	-1.7	-1.4	-1.7
Investment	-1.1	-1.4	-1.1	-1.3
Exports	-0.4	-0.8	-0.6	-0.6
Imports	-1.2	-1.8.	-1.3	-1.7
GDP	-0.9	-1.0	-0.9	-1.0
RGNDI	-1.1	-1.4	-1.1	-1.4
Terms of Trade	0.1	0.1	0.2	0.0
Real exchange rate	-0.2	-0.6	-0.2	-0.6
Real wage rate	-1.5	-2.0	-1.6	-1.9
Tourism exports	-0.9	-3.6	-1.0	-3.6
International freight exports	-1.3	-5.0	-2.3	-4.0
Emissions (excl international transport)	-5.7	-5.8	-5.8	-5.8

In terms of absolute numbers the fall in RGNDI between Scenarios A2 and T1 is about \$770m (in 2006/07 prices).[10] The direct loss of income from having to remit revenue from the carbon charge on emissions by New Zealand carriers is about \$215m, so we can deduce that the indirect effects of the tax wedge generate a cost of \$555m. This is partly attributable to the normal deadweight loss associated with a tax, and partly because export competitiveness is also affected by the tax on foreign carriers, even

[10] About \$150 per person.

though there are no net payments offshore for their emissions. To mitigate the fall in competitiveness the real exchange rate declines by 0.4% relative to Scenario A2.

Scenarios T2 and T3 tell a more subtle story. Pricing or taxing only international aviation (T3) has a much stronger negative effect than taxing only international maritime transport. The main reason for this is the balance of payments effect. As outlined in Section 2, even though most exports and imports travel by ship, the proportion of New Zealand companies involved in transporting people and goods to and from New Zealand by air, is much higher than the proportion of New Zealand companies in transporting goods (and a few people) by sea. Recall that it is only the tax on domestic companies that gives rise to a net balance of payments effect.

Apart from trade effects, Scenario T2 is barely distinguishable from Scenario A2. A \$50/tonne CO_2 charge on maritime emissions has only a very small effect on the overall landed cost of exports and imports. Export prices rise marginally more than import prices so there is a slight improvement (0.1%) in the terms of trade relative to Scenario A2. In Scenario T3 the terms of trade effect is reversed, falling by 0.1% relative to A2; reinforcing the negative effect of pricing international aviation emissions.

Tourism exports are not sensitive to a price on emissions from international maritime transport, declining in Scenario T2 by only 0.1% relative to Scenario A2. Most of the effect by far occurs in Scenario T3. In contrast exports of freight transport show a proportionately bigger effect in Scenario T2, but the aviation effect is still stronger. Again this is due to the greater carbon content of aviation.

In an earlier study a price on emissions from international transport was modelled directly as a tax on bunker fuels sales, projected to 2020.[11] A lower carbon price of \$25/tonne, also with no retention of revenue by New Zealand, led to a relative change in private consumption of -0.3% and a relative change in RGNDI of -0.2%. These numbers compare with -0.3% and -0.3% for Scenario T1 compared to Scenario A2. It is comforting to see this consistency of results albeit that the effects here are not double those of the previous study. This could be because of:

- The difference in how the carbon price is imposed – on incoming goods and people in relation to distance travelled, rather than directly on purchases of fuel – has smaller wider economic effects.
- Or that the newer underlying input-output table portrays an economy that is more robust to the effects of a carbon price on international transport.
- Or that the economy will be more robust to those effects in 2028 than in 2020.

Also in the earlier study, an emissions price on maritime transport had a greater effect on the wider economy than an emissions price on aviation, the reverse of what happens above in Scenarios T2 and T3. The main reason for this is likely to be that in the previous study the direct effect of the carbon price was to raise the price of shipping by 70% more than the increase in the price of aviation, whereas here the increase in the price of aviation is 46% more the increase in the price of shipping, a relative shift of 148% towards aviation.

[11] See *The Economic Effects of a Price on International Transport Emissions*. Infometrics report to Ministry of Transport. June 2010.

This difference in turn stems almost entirely from much lower fuel use (and thus emissions intensity) per tonne kilometre in sea transport than was previously the case, although the extent to which this reflects real (projected) efficiency gains versus better information is not easy to determine.

Group 2

Table 4 shows the results for Scenarios T5 and T6. Both scenarios look at a greater impact from a carbon charge, but by different means:

- Scenario T5 simply has a higher carbon price on international transport emissions – $100 instead of $50 in Scenario T1.
- Scenario T6 assumes that emissions associated with international maritime transport associated with New Zealand's exports are twice as high as calculated for Scenario T1.

Table 4: Group 2 Scenarios

	A2	T1	T5	T6
		Carbon price on international transport		
		$50	$100	$50
				↑ CO_2 shipping exports
		% Δ on Baseline		
Private consumption	-1.4	-1.7	-2.1	-1.8
Investment	-1.1	-1.4	-1.6	-1.4
Exports	-0.4	-0.8	-1.1	-1.0
Imports	-1.2	-1.8.	-2.4	-1.9
GDP	-0.9	-1.0	-1.2	-1.1
RGNDI	-1.1	-1.4	-1.6	-1.4
Terms of Trade	0.1	0.1	0.0	0.2
Real exchange rate	-0.2	-0.6	-1.1	-0.7
Real wage rate	-1.5	-2.0	-2.5	-2.1
Tourism exports	-0.9	-3.6	-6.3	-3.5
International freight exports	-1.3	-5.0	-8.7	-6.7
Emissions (excl international transport)	-5.7	-5.8	-5.9	-6.0

Scenario T5

A doubling of the emissions charge on international transport (but not on other emissions) approximately doubles the macroeconomic effects, including the depreciation of the real exchange rate. Hence for prices up to $100/tonne the effects of the charge are more or less linear. This is also true at the industry level.

Domestic emissions (that is excluding international transport emissions) are not sensitive to an emissions charge on international transport, merely reflecting the changes in GDP. So we may infer that the (minor) reconfiguration of the economy in response to such a charge does not significantly change its carbon intensity. In terms of the impact on the cost of emissions under any international responsibility target, each 0.1% change is equivalent to about 80kt, which is worth close to $4m at $50/tonne.

Scenario T6

Scenario T6, with doubled emissions intensity for shipping New Zealand exports is essentially akin to doubling the carbon charge just on that activity. Accordingly we would expect to see the economic effects falling somewhere between those in Scenarios T1 and T5. This is indeed the case although the mix of relative changes varies. For instance exports fall by 2/3 of the decline observed between Scenarios T1 and T5 (recall that tourism is unaffected in T6), GDP falls by half of the decline between Scenarios T1 and T5, and private consumption by 1/3. Real gross national disposable income is the same as in Scenario T1.

The invariance of RGNDI reminds us that Scenario T6 can also be interpreted as a sensitivity test on Scenario T1 with respect to the assumed carbon intensity of shipping New Zealand's exports. The greater fall in exports (about 50% more than in Scenario T1) has a negative flow-on effect on GDP, but this is offset by the more favourable terms of trade result in the calculation of RGNDI.

There is always a positive terms of trade effect from higher export prices, even when caused by taxes. It is possible that this can lead a to net welfare gain in spite of the accompanying deadweight loss and lower export volumes. Much depends on model closure and on which exports are affected.

While not a significant consideration in this instance, RGNDI is also affected by non-trade cross-border flows. In Scenario T6 the adverse balance of payments impact of the higher cost of emissions from shipping is offset by the larger fall in domestic emissions (6.0% v 5.8%) which reduces the cost to New Zealand of purchasing emission units from offshore.

Group 3

Table 5 shows the results for Scenarios T4 – unilateral action by New Zealand, and T7 where the revenue from the carbon charge levied in New Zealand is retained in New Zealand.

Scenario T4

As discussed in Section 3 the net macroeconomic result in Scenario T4 relative to T1 depends on a number of competing factors. As it turns out, the net effect is close to zero. Exports fall by relatively less in T4 compare to T1 as their competitiveness is partially restored, but private consumption falls by slightly more. The change in RGNDI is the same as in Scenario T1.

The terms of trade decline by 0.2% relative to Scenario T1, driven by higher import prices without any offset from higher export prices. This largely offsets the favourable effect of less revenue from the carbon charge being remitted offshore.

Tourism exports, which decline by less than in Scenario T1, reflect an interesting story. The absence of emissions charging by other countries means that the relative

50% price impact in Scenario T1 (see item 8, Section 2) is now 100%, but acting in the other direction, the tourists that do come to New Zealand now pay the carbon charge on only the incoming flight – a drop of 50% relative to Scenario T1. These effects essentially offset one another, with tourism receiving some additional assistance from the marginally larger drop in the real exchange rate.

However, as noted previously there is considerable uncertainty about how airlines would re-route flights and reconfigure their hubs if some countries impose a price on aviation emissions while other countries do not. Thus the model's results should not be interpreted as definitive.

Table 5: Group 3 Scenarios

	A2	T1	T4	T7
			Unilateral	Retain revenue
		% Δ on Baseline		
Private consumption	-1.4	-1.7	-1.8	-1.5
Investment	-1.1	-1.4	-1.4	-1.2
Exports	-0.4	-0.8	-0.6	-1.0
Imports	-1.2	-1.8.	-1.8	-1.6
GDP	-0.9	-1.0	-1.0	-1.0
RGNDI	-1.1	-1.4	-1.4	-1.2
Terms of Trade	0.1	0.0	-0.2	0.2
Real exchange rate	-0.2	-0.6	-0.7	-0.5
Real wage rate	-1.5	-2.0	-1.9	-1.9
Tourism exports	-0.9	-3.6	-2.9	-3.9
International freight exports	-1.3	-5.0	-4.3	-5.3
Emissions (excl international transport)	-5.7	-5.8	-5.9	-5.9

Scenario T7

Retaining revenue in New Zealand from a carbon charge levied in New Zealand (on incoming flights and sailings) is analogous to what happens under New Zealand's ETS. The only difference is that the emissions do not count against any international emissions responsibility target to which New Zealand might have committed.

As discussed in Section 3 the balance of payments effect of this configuration is significant, altering the effect from a net payment offshore in Scenario T1 to a net receipt. In effect New Zealand receives a free transfer from offshore. This produces a gain in RGNDI relative to Scenario T1. Similarly for private consumption and GDP.

In contrast real exports fall by more than in Scenario T1 – the other side of the slightly stronger real exchange rate. Greater inflows of foreign exchange not only affect the real exchange rate, but also – for a given balance of payments – allow resources to move away from export industries and into those that produce goods and services for household consumption.

5. Recommendations

Section 2 explained the various assumptions required to undertake the analysis and how the assumptions fit within the limitations the model. The areas that suffer most from a lack of good data are:

1. Market shares of domestic and foreign carriers, especially with regard to tourism.
2. The fuel intensity – and thus emissions intensity – per tkm of international shipping, as relevant to New Zealand's trade.
3. Freight margins, particularly on exports.
4. Substitution between short haul and long haul trips by tourists in relation to which countries might participate in an agreement to price international transport emissions (ITE).

The effects of changing maritime fuel intensity (item 2) were explicitly examined in Scenario T6, and complemented by looking at the effects of a higher carbon price in Scenario T5. While item 1 was not explicitly tested, its implications for the balance of payments and thus RGNDI were clearly shown by Scenarios T2-T3 and T7. Scenario T4 provides some insight into the effects of item 4, but this is a dimension of the topic that is probably better addressed with a multi-country model.

We have not tested changing assumptions about item 3, the overall freight margin on exports (as opposed to its carbon intensity in terms of emissions per tkm).

Delving into the origins of the difference between the 2010 and the current modelling (refer page 12) may also be useful in informing future policy development. Some of the possible reasons for these differences are likely methodological and establishing the importance of these assumptions would be useful.

Two other assumptions, while not specific to charging for ITE, but which nevertheless could affect the results are:

1. The underlying price of oil - higher or lower depending on the rate of development of alternatives or conflict in the Middle East.
2. A different initial share of tourism exports in total exports, perhaps because of different oil prices or the perceived attractiveness of New Zealand.

These two options would both require changes in the Baseline scenario as well as in any given ITE scenario, to prevent the effects of an ITE agreement being confounded with unrelated events.

Appendix A: The 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
- Faster technological progress
- Funding regimes for roading
- 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 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 2006/07.

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