A question of trust

Submission on the Zero Carbon Bill

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tailrisk economics
te maha hoki o nga pihikete

About Tailrisk economics

Tailrisk economics is a Wellington economics consultancy. It specialises in the economics of low probability, high impact events including financial crises and natural disasters. Tailrisk economics also provides consulting services on:

1. The economics of financial regulation

2. Advanced capital adequacy modelling

3. Stress testing for large and small financial institutions

4. Regulatory compliance for financial institutions

5. General economics.

Tailrisk also provides economic advice and analysis on public interest issues on a pro bono or reduced rate basis. This paper was produced in the public interest.

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Part one: Introduction

This paper is written as a submission to the Select Committee on the Zero Carbon Bill. However, its main purposes are: first, to review the quality of the official analysis that contributed to the some of the key decisions reflected in the Bill, and which will have affected the publics' understanding of the issues; and second, to focus on a number of the more critical issues that will arise as the New Zealand progresses to meet its targets.

In its Regulatory Impact Statement (RIS) the Ministry for the Environment (MfE) gives its work a high grade.

The Ministry and wider government have put significant resource and effort into developing a robust evidence base to underpin the Zero Carbon Bill proposals. This included: consulting scientific experts and literature; commissioning a range of sophisticated economic impact analyses and modelling; and undertaking an open and extensive public consultation process.

The scientific assessment of global climate change and its impacts, both internationally and domestically, is robust and credible, and has been subject to international peer review and quality assurance.

Our review presents a very different picture.

The MfE has systematically mispresented the impact of climate change on New Zealand. It has effectively suppressed, and misrepresented, the Intergovernment Panel on Climate Change (IPCC) reporting , and other 'unhelpful' analysis, and has failed to undertake essential research. None of its internal and commissioned research reports were peer reviewed, with the exception of the second stage NZIER report.

What emerges from our discussion is a persistent pattern of poor quality analysis. The MfE has variously, misrepresented, exaggerated, cherry picked, suppressed and

fabricated, evidence. We found that the MfE simply cannot be trusted. The MfE might think that a few white lies and shoddy analysis is acceptable in a good cause. The public needs to be jollied along, or frightened. We disagree. Ultimately it will corrode the broad consensus needed to achieve fair emission targets. If the MfE and the wider government can't be be trusted on the smaller, more technical issues, why should they be trusted on the big questions?

Organisation of this paper

Our discussion of the key issues covers the following:

Part two: The main proposals in the Bill

This part sets out our submission on the main elements in the Bill.

- Broadly we support the climate change targets, although there is room for debate about how we treat agricultural emissions.
- We have no issue with the Climate Committee proposals.
- The case for centralised adaptation co-ordination and reporting is overblown. For the relevant future there will be little to adapt to, and adaptation does not need a major centralised effort.

Part three: The Impact of climate change on New Zealand

The science on expected changes in New Zealand's climate is presented. This shows that claims that there will be far reaching and damaging changes are, for the most part, grossly exaggerated. The economic and social consequences of these changes have similarly been exaggerated. The most likely outcome, assuming some moderate success in mitigating global emissions, will possibly be a small positive effect. The MfE has made no serious effort to assess the overall impact of climate change on New Zealand and has deliberately suppressed evidence of positive effects.

Part four: Economic analysis of the effects of climate change policies

This part reviews the economic analysis that contributed to the public consultation process and to the decisions on the proposals in the Bill. Key findings are that the MfE fabricated evidence to make its preferred policy options look better; and that the results are primarily driven by the role of forest sequestrations, and overseas technical innovation. The contribution of forest sequestaions was suppressed to reduce their role. The economic analysis was a rush job, and future analysis needs to extend the modeling horizon well beyond 2050, integrate the best of the modeling analysis, improve transparency, attend to model weakness, and be more honest. Independent consultants need to be genuinely independent.

Part five: **The co-benefits of climate change mitigation**

A key MfE argument is that positive 'co-benefits' will offset much of the negative economic costs of mitigation policies. Our review of the MfE co-benefits paper found little evidence to support this claim. In particular we found that there are serious issues around the robustness of official estimates of the costs of air pollution in New Zealand. Excess deaths are estimated at 1000 per year but the World Health Organisation's estimate is only 20.

Part six: innovation and climate change

The MfE also argues that innovation induced by strong climate change action could give New Zealand firms a competitive advantage. The MfE's consultant's report largely refutes this argument. The MfE's review of the foreign literature claimed that it provide some support for the competitive advantage hypothesis. Our analysis found that the MfE often misunderstood or misrepresented the papers and contrary results were largely ignored. The literature does not support the MfE's position.

Part seven: The case for early and strong action

The case for early and strong action is based on:

- Co-benefit and innovation benefits, that largely don't exist.
- Claims that early adoption provides is a lower cost time path, which is largely based on some spurious Productivity Commission analysis
- New Zealand's self-appointed role of 'world leadership'.

While New Zealander's might be largely happy to do our 'fair-share', world leadership will have less widespread support. 'World leadership' is unlikely to make much of a difference to global outcomes, but could be used to promote expensive and largely ineffectual policies. The main beneficiaries of a global leadership role are the policy elite who will get to preen on the world stage. The losers are working people who will have to bear the cost of unnecessarily expensive policies.

Part eight: Reducing light vehicles emissions

Actions to reduce light vehicle emissions have just been announced, too late for an full analysis of the proposals to be included in this paper. Our initial assessment is that the policies are badly thought out, key information is not disclosed and the consultation document is often less than honest. The policies appears to be based, at least in part, on supposed market failures. A MfE report argues that new electric vehicles are no more expensive than internal combustion engine (ICE) and that various behavioral issues explain the limited uptake of new EVs. The MfE's cost claim was based on a single faked report. It is obvious that, at present, the lack of EV choice, vehicle capability and, especially, price are the real problems. These factors are rapidly changing, but for now EVs are an extremely expensive way (in excess of $1000 per tonne of C02) to reduce emissions. EV subsidies involving transfers from

working families to the higher income 'policy elite' are inequitable and will do little to advance the net zero objective.

Part nine: Climate Change and Defence

In this part we review the recent Ministry of Defence report on the 'climate crisis'. It is a case example of how climate change 'hysteria' has corroded the quality of analysis and decision making in the public sector. We found that the review was woefully inept. A 'comprehensive' eight month review was supported by just four references, none of which had much to do with climate change and security. Defence missed the key reference on the impact of climate change in the Pacific Islands that, amongst other things, suggested that there would be fewer cyclones and droughts. The report appeared to be a case of Defence 'singing for the supper', going through a largely meaningless climate change crisis ritual as part of a play for more resources.

Part nine: Actions we should take.

The best course for New Zealand is a slow and cautious mitigation path that will not put 'runs on the board' quickly. But governments tend to be impatient, and want to be seen to be doing 'something', regardless of cost or efficacy. In this part we present six low cost options. They are:

- Immediate action on imposing higher carbon prices on transport fuels with a time path for future increases;
- Taxes on international air travel;
- A ban on official business class air travel;
- Virtual attendance at climate change conferences;
- Replace the official 7 series BMW's with Nissan Leafs;
- Electrification of the tuk tuk fleet by 2020.

Some of the sections are lengthy because we have done a comprehensive 'fact check' on the MfE documents. Rather than presenting our own short summaries of their analysis, we have let the arguments speak for themselves, and have critically reviewed many of the studies that the MfE say they have relied on.

Part two: Submission on main provisions in the Bill

The emissions targets

We broadly support the targets set out in the Bill. We accept that climate change is real and that it is a global problem that requires a global solution. New Zealand has signed up to do its 'fair share', and we should meet that commitment. However, we do not accept most of the arguments that have been used to justify the targets. New Zealand will not be subject to significant harm from climate change in the medium term (this century); we should not be a global leader in the fight against climate change; there are not enormous co-benefits from policies to reduce greenhouse emissions; and there are not large 'first mover' advantages.

We do not need to resort to bogus or deluded arguments, or frighten the public with apocryphal visions of impending doom. Doing our 'fair share' is the right thing to do as a responsible member of the global community. That should be enough to justify the targets set in the Bill.

The Climate Change Committee

A Climate Change Committee almost comes with the emission target territory and we generally agree with the approach taken on the Committee's role.

Much will depend, of course, on how the Commission goes about its work. Decisions on carbon budgeting need to be based on quality analysis and a clear focus on least cost emission mitigation. What will it cost per tonne of emissions reduced should be at the centre of things. The Committee should not be swayed by the need to be seen to be doing 'something', when patience is required. And the Committee should stick to its knitting. Many proponents of climate change mitigation see this as an opportunity to effect some kind of more fundamental change in how New Zealanders live. A 'holistic' approach is almost the official doctrine. However, much of these broader agendas are only weakly related to achieving the climate change targets and are politically contentious. Signing up to the emission targets does not mean consent to a raft of other often dubious, 'holistically connected' initiatives.

We will get a sight on how the Committee might proceed is in the Interim Committee's first report due on 30 September 2019, which will cover the following:

- Building the foundations for emissions budgeting in the transport sector.
- Identifying data and modelling needs for the land use sector.

• Developing an economy-wide model and methodology for an economy-wide emissions budget.

There are contributions on these issues in this paper.

Adaptation co-ordination and reporting

The case for national adaptation reports and a coordinated national strategy is vastly overblown.

We are informed that a centralised approach is important, if not essential part, of any adaptation process, but without any real argumentation of justification.

The first question that needs to be answered here is adaptation to what. But in its many discussion documents and reports the MfE is evasive on this point, because the best science tells us not much will happen for several decades, and that some of the effects will be positive not negative.

There may be localised effects, and some implications for longer term infrastructure projects, but for the most part a centralised approach to long term adaptation planning, at this point in time, is a waste of time and a diversion from the central issue of reducing emissions at the least cost. In most cases the answer to the question ‘what are you doing now to plan for temperatures which are two degrees warmer; intensive rainfall events which are 10 percent more common, in 60 years time’, should be: nothing. To the extent that businesses need to adapt they will do so without the need for centralised planning and control. Climate adaptation is just one (mostly minor) risk, amongst many others, that businesses have to contend with.

But businesses and bureaucracies will probably go though a mostly vacuous box ticking exercise to be seen to be part of the ‘program'.

Adaptation reporting and control should be downgraded in the Climate Committees work programme. However, a useful early task the Committee would be set out a set clear, quantified, best assessment of future climate change and their likely effects, so people have clearing understanding of what is likely to happen.

Part three: The cost of climate change for New Zealand

The cost of climate change is discussed in two different contexts, which are not always clealy distinguished. First, estimates are used to the justify the world taking action, and typically assume no further action to reduce emissions.

The second, most relevant for in the context of the adaptation discussion, is the cost of adapting to climate change, even if global emissions mitigation is successful, or partially successful. Here we are talking about a temperature increase of one degree or more likely two degrees, and the costs (and benefits) are lower than if no action is taken.

The first step in any climate change cost assessment is, obviously, to establish what kind of climate changes we are talking about.

The IPCC (intergovernmental Panel on Climate Change) has produced a number of representative emissions pathways (RCPs) reflecting the success of various mitigation efforts, on emmission concentrations. RCP 2.6 assumes a rapid reduction in emissions, and the withdrawal of some of the C02 presently in the atmosphere; two stablisation pathways, RCP 4.5 (C02 stablises at around 500 ppm in the second half of the century) and RCP6.0 (700 ppm by end of century and still increasing) represent different degrees of success in reducing emissions; and RCP 8.5 essentially assumes no climate change mitigation (1000 ppm and still increasing strongly).

These emission pathways can be run through climate models to generate climate change scenarios consistent with the pathways. The definitive analysis for New Zealand is set out in the MfE document *'Climate Change Projections for New Zealand: Atmosphere Projections Based on Simulations from the IPCC Fifth Assessment 2018.'*

Because the estimates of climate changes in this document are often ignored, or misrepresented, we present a summary below. Obviously the MfE should have presented a summary in its more public documents. But it did not do so, prefering to talk in more general terms about increases in extreme weather events, leaving the impression that we are in for some truely severe and damaging changes.

The summary headline figures in MfE adaptation report are shown as a range of the 2.6 and 8.5, RCPs, which is not particularly helpful for understanding what is likely to happen in New Zealand. The RCP 2.6 is no longer a serious possibility and the RCP 8.5 is unduly pessimistic about the possibility of some effective international action.

The MfE's position in the RIS is that the failure of global mitigation efforts is unlikely. We have extracted the more relevant changes from the body of the report. The base for the reported changes is the 1985-2005 average.

Table one: Summary of climate changes

RCP		**4.5**	**6.0**	**8.5**
Temperature increase 2040		0.8	0.8	1.0
Tempeature increase 2090		1.4	1.8	3.0
'Hot' days >25oC Auckland Wellington	Base 20	36-48 (2040-2090) 29-35	35-59 28-41	39-90 31-60
Overall precipitation	Very small (0-5 %) changes in most places			
Dry days	Increases in most places average around 10 days –but variable			
Droughts	Drought was only reported for RCPs 2.5 and 8.5. In general the risk of drought are higher in already drought prone areas.			
Moderately extreme daily precipitation Determined from the 99th percentile on wet days,	increases over most of the country except for parts of Northland and Hawke's Bay. Increases are small for the remainder of the North Island, larger for the South Island, and largest of all (20 per cent or more) in the south of the South Island.			
Very extreme precipitation Very Extreme	Falls with the duration of events from about 13 percent for 1 hour to about 6-7 percent for longer duration 72			

precipatation is expressed as the percentage increase per degree increase in temperature	-96 hour events that can result in major floods.			
Storms	Information on frequency is limited. There may be a small increase			
High winds	Up by 10% or more in parts of the country			

The 'hot days' benchmark of 25oC is reflective of an official bias to talking up the evidence. Elsewhere 40oC is the typical benchmark for temperature extremes which could pose a threat to health. In New Zealand the benchmark merely reflects an increase in the number of pleasantly warm summer days.

Overall, the summary does not show a systematic pattern of extreme changes and we would not expect hem to have a strong economic impact.

Economic and social impacts

Now that we have a better sense of the magnitude of climate changes we examin discussions of the evidence on the economic and social effects under the following headings.

1. The MfE's assessments in Our climate and the RIS.
2. The Australasian section of the 5th IPCC report
3. Impacts on the agricultural sector.
4. A Treasury commissioned report on some costs of climate change to date.
5. The MfE's Adapatation Technical Working Group's report.
6. The amenity effect of climate change

1. The MfE on the cost of climate change

The MfE has not produced an overall economic assessment of the costs of global warming for New Zealand. They have said that it would be 'too hard to do'[1], and that there are no available studies.

This is disingenuous. The MfE has commissioned lengthy reports on several complex

[1] In an op ed in the Dominion last year Jim Rose reported that both the Minister and the Ministry had been

issues, and could have produced a report on the costs if it wanted to. But they didn't, most likely because they knew that any honest and competent analysis would not have generated large net costs, and the overall benefits may well have been positive. The MfE did not even attempt to summarise, in its public documents, the New Zealand impacts reported in the IPCC's 2014 report.

The OECD report

All the MfE did in its Regulatory Impact Statement (RIS) was cite, and then misrepresent, some results from a 2015 OECD report on climate change costs. In the overview section of the RIS, the MfE made the following statement:

The cost to the New Zealand economy of no further action on climate change (by New Zealand and the rest of the world) is estimated by the OECD as a reduction in Australia and New Zealand's combined GDP growth rate of 1–2 percent per annum by 2060.

This is false. The OECD results refer to of the impact of climate change on the absolute level of economic activity, not a reduction in the growth rate. The differnce is fundamental. For Australasia, the underlying growth in GDP assumed in the OECD report, is 2.6 percent per annum over 2020-40, and 2.1 percent over 2040-60. By 2060 the economies will have grown by 153 percent. The OECD's central estimate of the climate change effect is about 0.8 [2]percent. So with climate change the economies grow by 151.8 percent. Climate change does not make a big difference.

In a more detailed section of the RIS, the MfE does understands the difference between the absolute level of GDP and the growth rate. It is concerning that the obvious misrepresentation of the OECD results was allowed to stand in the more accessible level of the RIS.

The second issue is the MfE's representation of the uncertainty around the OECD's central estimate of the economic cost. The impact is described as 1-2 percent. The actual reported uncertainty band around the central estimate of 0.8 percent was 0.3 - 1.4 percent (reflecting different temperature increase outcomes). There is a 2 percent impact, but this assumes an extreme, 6oC temperature increase. No official source is forecasting that outcome.

The third issue is that the Australasian numbers are dominated by Australia, which as an already hot country, will be more affect by climate change than New Zealand. One of the takeouts from the OECD reports, and similar studies, Is that the northern countries, which are the best comparators for New Zealand, are not negatively affected by climate change. The Treasury raised the issue of the legitimacy of the

[2] The results are only presented in a figure in the OECD report, and it is difficult to read them off precisely

MfE's use of Australasian results from the OECD report, but without success in terms of improving the intergrity of the RIS[3].

Finally, the OECD's headline numbers excluded the carbon fertilisation effect (higher Co2 levels in the atmosphere can increase production) on agricultural output. The OECD rather grudgingly made a partial allowance for this, and it still had a material impact on the overall results. The carbon fertilisation issue is discussed further below.

Evidence presented in 'Our Climate'

Despite the lack of a solid overall assessment, Our Climate, which was the public face of the MfE's analysis, tried to leave the impression that the costs are large and justified early action. There were four pieces of 'evidence'.

Impact on Global GDP

Recent analysis also suggests that limiting global warming to 1.5 degrees Celsius instead of 2 degrees Celsius by mid-century could lead to an increase in global GDP of 1.5 per cent to 2 per cent and avoids damages from climate change globally of around $11 trillion to $16 trillion.

We have read the 'recent analysis'[4]. The methodoloy was to estimate a simple relationship between variations in annual average temperatures and annual changes in GDP, in a panel of 165 countries over 1960-2010. It uses this relationship to calculate the difference in GDP when the temperature increases by 1.5 degrees and 2 degrees.

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[3] OIA request re above 20 November 2017 . Treasuey questions on draft of Cabinet paper

Para 22: OECD – costs of inaction.
a. We were a little puzzled as to why the figure of 2% reduction in GDP was cited, in terms of the costs of inaction. Is this taken from the OECD's analysis of the macro consequences of climate change impacts, as described in Ch 2 of the 2015 report? In this report, the OECD notes that the costs of inaction of 2% GDP is a global average loss, but then goes on to say that the losses to OECD
economies are much less. The OECD states that "The economies of OECD countries are, on balance, much less affected, with losses in 2060 amounting to -0.2%, -0.3% and -0.6% for OECD Europe, OECD Pacific [NZ is included in this group] and OECD America, respectively, not least because many of
these countries like in temperate climate zones." (para 2.2.1, p53)
b. We were also a little puzzled about the logic of including this 2% global average figure. This leads the reader to think that taking climate action in NZ would avoid us suffering a 2% GDP loss (or 0.3% loss based on the above para.) However, as NZ produces only a small proportion of global emissions, it is
possible (and indeed likely) that even if NZ was to shift to net zero emissions tomorrow, we would still suffer the same macro impacts as we would if we continued to emit as we do now, the impacts of climate change that NZ experiences are not a result of NZ specific emissions.
c. These concerns are in addition to our concerns with the underlying data that the OECD report is based on, with regard to the conflation of NZ and Australia – for two examples, some of the modelled losses are attributable to a) extreme events (incl heat waves and tropical cyclones) and b) impacts in the energy sector (especially oil, gas and coal) where there are clearly greater impacts for
Australia than NZ.

[4] Burke 2018

There are a number of problems in drawing any inference from this paper for New Zealand. First, the results will be heavily influenced by underdeveloped countries in hot areas of the globe. While it is plausible that there was a historical relationship between temperature and short run variations in economic activity in these countries, it is a big step to claim that these results apply to a slow secular increase in temperature in all countries.

Second, the results suggest that for New Zealand there will not be a material impact. The paper shows an inverted U shaped relationship between temperature change and GDP changes. There is an economically 'optimal' annual average temperature of 13.1 degree C, where there is no economic impact. New Zealand sits close to this climatic sweet spot. If the MfE wanted to cite this paper then they should have have presented the whole story.

Drawing conclusions from recent events

Our Climate goes on to make a case for negative impacts under the heading 'Impact of climate change so far'.

We are already feeling the effects from a changing climate. In the past 100 years, seas have risen around 14 to 22 centimetres in New Zealand ports. More recently, we have suffered costly damage and disruption from coastal erosion, more frequent and severe weather events (flooding, droughts and wildfires) and damage to infrastructure and assets.

While it is true that sea levels have risen, it cannot simply be assumed that recent weather events have been due to climate change, any more than it can be said that unusual cold snaps refute the global warming hypothesis. However, the Treasury has attempted to fill this gap by commissioning a paper that attempts to estimate the impact of climate change, since preindustrial times, on the likelihood of more extreme weathe events over the last deade. We consider this report in detail below.

Transport costs

The costs we face are continuing to rise. As an example, in the past 10 years, the cost of weather events to our transport network has risen from about $20 million per year to over $90 million per year.[5]

The source of the $20 to $90 million increase in the cost to the transport network was a 2017 MfE report[6]. That document in turn referenced a Ministry of Transport report as the source. That document was written in 2009, so it did not, and could not, provide evidence on the costs over the 10 years to 2018. In any event storm

[5]Ministry for the Environment (2017).

damage to the transport network is highly variable from year to year, so an increase from a given point to another point 10 years later, proves nothing about the trend.

Cost of sea level rise

Reports from the Parliamentary Commissioner for the Environment indicate that the cost of replacing every building within half a metre (above current sea level) could be $3 billion and within 1.5 metres as much as $19 to 20 billion.

The value of buildings 'at risk' is interesting, but is not the important data. We need to know how much it would cost to defend those buildings, or when it is appropriate to retreat, the value of the abandoned properties. In that respect there is some useful information in a report by Beca Ltd. to the Dunedin City Council [7](2014).

Their broadbrush assessment of the costs of dealing with a 0.8 metre sea level rise (0.6 metres is the projected rise by 2100) are a capital cost of $75 million and $3.5 million a year in running costs. The value of buildings at risk was over $1 billion.

Unfortunately, there is no broadbrush overview of these costs on a national scale, that would inform the climate change policy debate. However, to get a sense of the scale of the problem, let us assume that the future cost is, say $10 billion for coastal protection and land loss. These costs will be incurred in the future, and in some cases well into the future, but say the average delay is 40 years. Using a 6 percent discount rate, which is conventional for this kind of investment, the present value of the $10 billion is $840 million. With a 30 year delay the cost is $1560 million. These are not big numbers compared to, say, the cost of improving Auckland's transport infrastructure. The Auckland City rail link project is now estimated to cost $4.4 billion.

Local Government New Zealand has recently released a report[8] on the replacement value of local government infrastructural assets exposed to varying sea level rises. The more relevant numbers are $2.7 billion with a 0.5 metre rise, and $5.1 billion with a one metre rise. Again, these are just estimates of the replacement assets at risk. They are not estimates of the economic costs of the sea level rise. Some of the assets may be economically defended, and some may be relocated, with a more limited marginal cost, as part of normal maintenance and replacement cycles. Necessary expenditures will take place over many decades.

[7] Beca Ltd. 2014

[8] Simonson T and Hall G. 2019 'Vulnerable: the quantum of local government infrastructure exposed to sea level rise' LGNZ Survey and support by Tonkin & Taylor Ltd

There is an estimate[9] of the cost of adaptations to rising sea level for the EU. The numbers are not too frightening.

The annual cost of adaptation has been estimated at €1.5 billion in the 2050s (EU, current prices, undiscounted), and achieves a benefit-to-cost ratio of 6:1 (A1B(I) mid scenario). The benefit-to-cost ratios increase throughout the 21st century. However, hard defences need ongoing maintenance to operate efficiently and to keep risk at a low or acceptable level. As the stock of dikes grows throughout the 21st century, annual maintenance costs could approach or exceed annual incremental costs.

Wildfires

The only information we have on the cost of wildfires is the following statement in The Westpac report[10] cited in Our Climate.

The most serious risk faced by the Forestry sector is the increasing likelihood of bushfires, as days with a fire index of 'very high' and 'extreme' will increase in some New Zealand locations up to 400% by 2040 and 700% by 2090 like the 2017 Port Hills fire in Christchurch and the 2015 and 2016 Marlborough fires are expected to occur with increasing frequency and severity. Over the last 70 years, wildfires have cost the forestry industry at least an estimated NZ$300 million and 40,000 hectares of plantations.

The assessment of the higher incidence of fires was taken from the Australasian chapter of the fifth IPCC report. The estimated increases were 0-400 percent and 0-700 percent respectively.

The average cost to the forestry industry was $4.4 million a year, though the total cost of the fires will be bigger than this figure. Even if the annual costs were three or four times as big by 2100, this would still not be material in terms of the larger economy. In terms of insured losses, the only fire events recorded by the New Zealand Insurance Council as disaster events in the last 50 years, were the 2017 Port Hills fire which cost $18.3 million and the Tasman 2019 fires, which cost $3.9 million.

Droughts

The 2013 drought in the North Island cost the economy around $1.5 billion, and climate change will make droughts like this more likely.

Droughts are discussed in 3. below.

The above was the entirety of the evidence base on the costs of climate change that was presented to the public.

[9] Brown 2012

[10] Westpac 2017

2. The Fifth Intergovernmental Panel on climate report: Chapter 25 on Australasia

Some of the information and analysis that would inform an assessment of the extent of climate change, and its effects, is set out in chapter 25 on Australia and New Zealand, in the Fifth Intergovernmental Panel on Climate Change report. This should have been the 'go to' document for the Ministry and many other commentators. It was obviously not written by 'climate change deniers', so it can be relied on not to understate negative climate change effects.

To assist the reader, and to avoid accusations of cherry picking, we have set out, in appendix 2, nearly all of the New Zealand material in the report. We have only excluded some technical detail that does add to the substance of what is being said. We have commented where appropriate.

3. Impact on agriculture

The Ministry of Primary Industry report on climate change impacts

The IPCC reporting on the impacts of climate change on land-based industry is fragmentary, and mostly omits hard numbers. It does not come to an overall conclusion, but leaves the impression that the impact is negative. A more comprehensive and balanced assessment is in the Ministry of Primary Industry's 2012 report '*Impacts of climate change on land-based sectors and adaptation options: Stakeholder report'.*

The main purpose of the report was to look at adaptation and resilience issues, rather than to make an overall assessment of the economic costs and benefits, but two major themes suggest that the overall impact could be positive. The first is that CO2 fertilisation will have a positive impact, and in many cases this impact will be material. The second is that New Zealand farmers are very good at adapting, both tactically and more strategically, to climate events. This would help mitigate some of the adverse impacts, which are, in any event, less quantitatively significant.

On CO2 fertilisation the report says

Increased carbon dioxide (CO_2) concentrations affect all land- based sectors. They mean higher potential growth of biomass for many key crops, pastures and trees in the future. This is known as 'CO_2 fertilisation'.

- *Higher CO_2 concentrations stimulate plant photosynthesis and growth.*
- *Pasture, tree and crop varieties do not respond equally to changes in CO_2 concentrations. The effect is stronger in C3 plants (ryegrass, clover, wheat, kale) than C4 plants (maize,*

kikuyu).

- *Plants close their stomata to cope with the increased CO_2, transpiring less water in the process. CO_2 fertilisation also stimulates more growth per unit of water, making plants less water-dependent.*

In pre-industrial times – before around 1870 – atmospheric CO_2 concentrations averaged 280 parts per million (ppm). In early 2012, they measured 390 ppm. By the 2050s, those levels could climb to between about 475 and 565 ppm; and by the 2100s, to between 540 and 955 ppm. The CO_2 fertilisation effect is well documented from greenhouse production systems, where the environment is controlled.

Estimates of the net effect of CO_2 fertilisation vary widely. For New Zealand pastures, estimates range from 5 per cent to 30 per cent increases in above-ground biomass for a doubling of C02.

For pastoral farming, management practices will have to evolve to maximize the potential benefits and to mitigate the downsides. Seasonal rainfall patterns will change towards drier summers and there will be more droughts. In the most productive areas the incidence of short-term summer droughts are expected change from around one year in twenty to one year in ten.

For some other products the impacts are clearly positive.

Assuming adequate water and soil nutrient supply, potential yields of temperate cereal crops could increase by as much as 20 per cent under future temperature and CO_2 concentrations.

Similar potential yield increases are projected for forage crops, like winter cereals and brassicas, which are harvested in a vegetative state and have longer periods to grow, thanks to the shortening of cycles of adjacent annual crops.

For other crops and locations, climate change effects were more variable, and some were slightly negative. Without adaptation, yields of forage crops, such as silage maize, along with more temperature-sensitive crops like potatoes and peas, are reduced under some climate change scenarios.

For horticulture the impact is probably neutral.

The main impacts on apple, kiwifruit, and grape growers will be increases in vegetative biomass, pest/disease risks and changes in plant development.

The sector has considerable adaptive capacity, in that growers can relocate and expand relatively rapidly, as exemplified by the recent spread of vineyards.

The most positive effect is on forestry.

With higher concentrations of atmospheric CO_2, radiata pine productivity is expected to increase in most plantations by an average of 19 per cent by 2040, and an average of 37 per cent by 2090. South Island plantations will receive additional benefit as warmer temperatures boost photosynthesis. Precipitation might decrease in some areas, but this can, up to a point, actually improve productivity, as trees use water more efficiently. However, where water or nutrients are in short supply, productivity will fall.

The MfE's assessment

All of the positive effects of CO2 fertilisation were airbrushed out of the Ministry's 2017 economic assessment of the impact on the agricultural sector. It reads as follows:

primary industries are particularly exposed to the impacts of climate change. For example, they are strongly linked to freshwater availability, and climate change is expected to increase competition for freshwater resources (RSNZ, 2016). While the severity of impacts will vary by sector and region, the risks and costs from extreme weather and wildfires are expected to increase across all land based sectors and supply sectors will be affected by impacts which interfere with the ability to get primary products from the farm to processing facilities and then to markets or ports. Climate change impacts may affect transport (for example due to storms and slips closing routes) and also the operation of processing facilities (for example interruption to the supply of energy or water required for processing).

This obviously presents a misleading picture of the implications of a warming climate. The MfE knew about carbon fertilisation but entirely ommitted it, and any reference to the Ministry of Primary Industry report, from its assessment.

4. Estimates of climate change-related weather event costs[11]

One study, reported in the RIS, actually provided some relevant quantitative evidence on the impact of climate change on New Zealand. Oddly, it was commissioned by Treasury rather than the MfE. Treasury were unable to explain why they, rather than the MfE, commissioned the research. Whether it was an attempt to bolster some flimsy MfE assertions about the impactof extreme weathe events, or alternatively, an attempt to expose the MfE's exaggerations, we do not know.

The basic idea in this paper is that the effect that anthromophic influences over the last century are currently having on extreme weather events can be identified, and

[11] New Zealand Climate Change Research Institute[11], and NIWA. The Climate Change Research institute appears to be a collection of a few VUW accademics with no online prescence other than a single page on the VUW websire

the cost of that impact calculated. The methodology, which is described as preliminary and indicative, involves, as we understand it, using a particular climate model to disentangle the natural (preindustrial) weather effects of actual extreme weather events, from the man-made effects that have caused a rise in temperaures of nearly 1 degree C over the last 100 years. For flooding, which is caused by extreme rainfall events, the result was that additional insured costs increased by an average of $12 million a year, based on 2007-2017 events.

This is an economically inconsequential number. To put it in context, the expenses of the New Zealand non-life insurance sector are about $4.5 billion a year. The $12 million does not capture the full economic costs of the floods, but it is the relevant number for a discussion of the effects of global warming on the insurance sector.

The estimate of the increase in drought costs is substantially bigger than flooding, at an average of $72 million a year. The methologoly is based on a single paper (Harrington et al. 2016) and two droughts were considered. The first, the 2012-13 drought, is estimated to have a FAR (an estimate of the proportion of the cost caused by climate change) of 0.2. Given the economic cost of the 2012-13 drought of $1.5 billion (estimate provided by Treasury), the excess cost due to the anthromorphic influence is $300 million.

There is no real analysis of the 2007-8 drought, which had an estimated cost of $2.5 billion. It appears that this drought was affected by the el Nino effect, which the model doesn't handle well. Instead a lower FAR of 0.15 was just assumed, for an excess cost of $420 million. Adding the excess cost of the two events and averaging over 10 years generates the annual cost of $72 million.

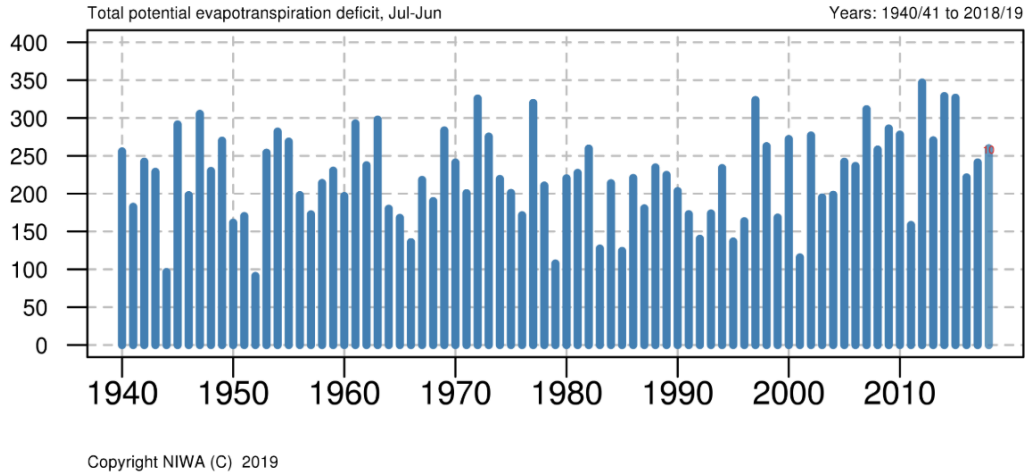
One problem with this analysis is that no attempt is made to assess the probability of extreme drought events. The particular ten year window chosen just happened to have two extreme drought events (implying a one in five year incidence), but if the 'true' underlying frequency was, say, one in 20 years then the average annual cost would fall by a factor of four to $18 million. Even sticking with an observed ten year window, the 2007-8 event would drop out if the model were updated and the annual average cost would drop to $30 million.

Second, there is no literature review. There is one in Harrington, which suggested that evidence that attributes drought events to climate change is lacking. Harrington's contribution is a new methodology that he claims establishes the climate change/drought link, but it has its limitations.

We emphasize that these results are sensitive to the threshold at which FAR was calculated, and discernible changes to likelihood in the extreme tail of the distribution could not be reliably identified by using the model ensemble available.

Third, there is no descriptive analysis of the historical evidence of the extreme events, which should be a standard part of any analysis. If we look at the NIWA historical data on soil moisture deficits, there does not appear a very obvious trend in drought conditions. The modelling results needed to be reconciled with this data.

Figure one: NIWA drought history



Fourth, there is only a rudimentary treatment of confidence intervals. Individual weather events are complex affairs and there must be a wide degree of variability in any attribution analysis.

There is no forward looking analysis, although the implication is that worse is to come. But this does not seem to be consistent with the IPCC models, which suggest only a moderate increase in 'extreme' weather events even over long time horizons even assuming more extreme temperture increases. There should have seen some attempt to explain, and if possible, reconcile these differences.

The paper also discusses climate impacts more broadly.

Because no NZ-based peer-reviewed papers yet exist investigating the FAR associated with storm damage, hailstorms, wildfire, frosts or tornadoes, we have left these out from the analysis. Our neglect of such events means we ignore at least NZ$279M in weather-related losses between July 2007 and June 2017. As an indicative comparison, if the FARs associated

with these events were similar to those in the table – around 0.3 – then the extra attributable losses would add another $84M.

This excess cost 'guess' has yet to be demonstrated, but even if the estimate is reasonable, at $8.4 million a year, it is still not economically consequential. And even if we scale up the insurance losses for other economic losses we do not get numbers that come anywhere near justifying the 'adaptation hysteria' we are seeing.

Wider climate impacts

There is also discussion of a wider climate change impacts research programme which reads a little like a research sales pitch.

All of the identified impacts are negative. Notably, there is no discussion of the positive effects of carbon fertilisation or any thought given to the amenity affect of warmer temperatures and more fine days.

To highten the importance of the research programme, the report sets out the 'headline' impacts from the Australasian region in chapter 25 of the 2014 IPPC report. These are almost entirely based on Australian impacts, which are much more dramatic and negative than New Zealand's. If they had reported the New Zealand impacts, as we have, it would not have helped the sense of the necessity for more research that they were trying to build.

As it turns out the modelling team have been successful in getting further funding. Specifically, a $999932 three year grant from the Endeavour Fund

*'to develop an Extreme Weather Event Real-time Attribution Machine'(**EWERAM**) where, within a day or two of an EWE having occurred over New Zealand, and in response to media questions about the role of climate change in that event, rather than generic statements, scientifically defensible data will be available to inform quantitative statements about the role of climate change in both the severity and frequency of the event'.*[12]

The sales pitch/synopsis reads as follows:

,… knowing to what extent a recent extreme event was made more severe and/or more likely because of climate change, will allow New Zealanders to better anticipate and prepare for extreme events to come, and will sharpen awareness of the necessity for reducing greenhouse gas emissions that drive climate change. We will develop a capability where, soon after an extreme weather event, the contribution of climate change to the likelihood

[12] Boedeker Scientific website: accessed 10 June 2019

and severity of that event will be quantified in a scientifically robust way and widely communicated to New Zealand society.

How being told that a flood event is estimated as having, say, a 26.2 percent likeihood of being caused by historical climate change will lead to a deeper understanding of the effects of climate change is beyond us. The exercise is obviously designed to exploit the newsworthiness of weather events to drive the climate change message. It is a public relations ploy.

We doubt that 'New Zealand society ' will be told something like the following:

'*The EWERAM model [13] shows that 26.2 percent of the recent Manawatu flood could be attributed to the global warming that has occurred since 1850. The confidence interval around this estimate is 12.1 to 40.6 percent, so there is a high probability that past climate change had no influence on the outcome. The estimate is based on a single climate model. Other models may not show any climate change impact. Based on past events of a similar size the financial cost of the flood attributable to climate change will be $3.2 million or about .003 of one percent of GDP.'*

5. Climate Change Adaptation technical working group: Adapting to climate change in New Zealand

The MfE might argue that the consultation document and RIA were just overviews and that there is more extensive analysis of the affects of climate change in the Climate Change Adaptation Stockstake report[14]. As this report also provides the underpinnings for a strong centralised approach to climate change adaptation we discuss it here.

Chapter two of the report covers future climate changes, taking information from the MfE climate projections report for New Zealand discussed above. The Technical working group says that climate change outcomes are uncertain, and their document just presents the ICPP's low and high emissions scenarios as representing the range of possibilities. Most of the outcomes are expressed in qualitative terms ('there will be an increase'), or a range is given (temperature increases of 0.7-3.7oC by 2110. Mostly the hard data relates to the most extreme RCR 8.5 outcome, where the Paris

[13] The EWERAM model is not an attractive hermaphrodite sheep. EWERAM is a acronym for the climate model.

[14] Adapting to climate change in New Zealand: Stocktake report from the Climate Change Adaptation Technical Working Group

agreement is assumed to completely fail. There is no data at all in the discussion of increases 'extreme' weather events in the body of the report.

Chapter three addresses the impacts of the climate changes. This was almost entirely a 'post-it note' exercise. It is a collection of possibilities with few connections to actual climate outcomes, or to when they might occur, and there is almost no quantification of the impacts. One exception was a comment on the fishing industry.

Primary production in open ocean surface water is projected to decline by an average of six per cent from present levels by 2100 under a high global emissions scenario, as a result of ocean warming and acidification.

A possible six percent fall in the fishing industry production, in a worse case scenario 80 years from now, is hardly something that should exercise minds in the fishing industry.

The post-it note approach might be useful for getting some preliminary possibilities up on the board, but not very helpful for getting a sense of the overall impact of a defined climate change scenario.

Despite the lack of hard analysis the Working Group came to some strong conclusions on the overall impact of climate change. The following is the full discussion in their section 3.3.5

While the potential costs of climate change impacts for New Zealand are not known, we do know that our exposure to the impacts of climate change ***is high*** (our emphasis) *, particularly in certain areas (eg, at the coast, within the built environment and to our major economic sectors), and as such* ***the costs will be significant*** (our emphasis*). For example, the value of assets that will be affected by sea-level rise is estimated to be in the billions of dollars, and the costs of weather events to the land transport network have increased in the last 10 years from about $20 million per annum to over $90 million per annum*. (As discussed above there was no such evidence on the latter point*).*

The associated costs of three extreme events in New Zealand to which climate change is assessed to have made a contribution are:
• 2011 flooding in Golden Bay: estimated cost $16.8 million
• 2012–2013 drought which affected the entire North Island and the west coast of the South Island: It was one of the most severe experienced in these areas in at least 40 years. The economic impact of the drought is estimated to be a minimum of $1.5 billion (Treasury)
• 2014 flooding in Northland: estimated cost $15.1 million.

The sourse of these 'assessments' are not cited

The increased frequency and intensity of large extreme events has the potential to increase the scale of costs significantly, especially (this ignores the evidence that increases extreme weather event will be quite moderate) *that if the coping capacity between events is challenged. The much greater frequency of smaller events could represent an even greater cumulative cost.* ***Overall, the costs to New Zealand of climate change impacts and adapting to them are expected to be higher than the costs of reducing greenhouse gas emissions*** (our emphasis).

There is simply nothing in the analysis to support this conclusion.

Health effects

We also present the assessment of health effects in its entirety to give the reader a sense of the sweeping statements, and lack of substance behind the claims of the effects of climate change, that pervades the document.

Public health Climate change is increasingly being recognised as a serious emerging risk to public health globally and in New Zealand. Some of the potential impacts will be direct, such as injury and illness from extreme weather events or increased heat-related deaths (although winter-related deaths are expected to decline). There are also indirect risks including increased incidences of existing and new diseases. Climate change brings changes to disease vectors worldwide. A warmer and wetter New Zealand means that we will experience diseases not currently present in New Zealand and potentially more frequent pandemics. These impacts will lead to intensified pressures on our health system. Other indirect risks include increasing stress and mental health issues, for example, as a consequence of extreme weather events, sea-level rise or loss of livelihoods.

The only supporting 'evidence' for these claims is a paper, 'Climate Change and Health in New Zealand (2013)'. from the New Zealand College of Public Health Medicine[15].

We reviewed this document and found that it was similarly full of unsupported statements. In an extensive set of references we were unable to find any that provided actual evidence of specified climate change impacts on health in New Zealand. The document is more about promoting the NZCPHM self appointed mission than providing an evidence based assessment of the implications of climate change on health.

The NZCPHM has a responsibility to ensure the public health and equity consequences of climate change areunderstood, to lead in preventing and preparing for those consequences, and to promote the substantial population health gains that can be achieved from appropriate climate change action. Climate, health, and equity are inseparable. Addressing

[15] New Zealand College of Public Health Medicine is an incorporated society without any apparent offical status.

climate change should be an essential component of health policy. Similarly, health and equity outcomes must be key priorities within climate change policy.

6. The amenity effect of climate change

The positive amenity effect of climate change has not been considered in any of the Ministry's assessments (or generally elsewhere). The Fifth IPCC report, however, noted that a warner climate had been identified as one reason for New Zealand migration to Australia.

New Zealand has relatively cool and unreliable summers. While higher summer temperatures and droughts are an issue for farmers, they are a boon to holidaymakers. The summer of 2017-18 was perhaps a portent of things to come. Many people loved it and are looking forward to a repeat. Many people too will be happy if the winter chill is reduced by two or three degrees.

With climate change, perhaps not so many people will go to Queensland and elsewhere in search of better weather. It may also have an impact on internal migration. Southerners will not have to go Auckland for a bit more warmth. Auckland's weather will come to them.

In general a warmer climate will be good for tourism and cooler climate counties like New Zealand will benefit. For an analysis of this effect, for example see Bigano (2008)

A survey of international tourist found that New Zealand was cooler and wetter than they expected, so one of the co-benefits of increasing temperatures, and more dry days might be happier tourists.

Conclusions

The MfE has not presented any substantive evidence that climate change will have major negative impacts on New Zealand this century. The effects are more likely to be positive than negative.

- The increases in extreme events are much less than often claimed or insinuated.
- The evidence presented in the IPCC report does not support a conclusion that the global warming impacts would be strongly negative, or even negative at all ,for New Zealand.
- The present value of costs relating to sea level rises, is not large in relation to the economy.
- Health costs are trivial and are more likely to be positive than negative.
- Most importantly, carbon fertilisation will have a positive impact on

agricultural production.

- There will be amenity or 'well being' benefits for most from a warmer climate and more rain free days.
- The tourism industry is likely to benefit.
- Other things being equal, the terms of trade are likely to turn in New Zealand's favour, as agricultural production in hotter climates is disproportionately affected by temperature increases

Part four: Economic analysis of the effects of climate change policies

The MfE primarily relied on two sets of external economic analyses by CMV's (a consortium of three consultancies: Contact, Motu, Vivid) and the New Zealand Institute of Economic Research (NZIER).

CMV analysis

The first stage paper analysed different paths to 2050 emissions targets under different assumptions. It calculated the consequent emission prices, and the impact on land usage. This analysis was presented in the Our Climate consultation paper. This analysis is now dated because the scenarios do not match those in the Bill.

The second stage paper 'Modeling the transition to a lower net emissions New Zealand: Uncertainty analysis' presents an analysis of three scenarios that are imposed on the model up until to 2030. It then lets the models run to achieve a specified 2050 emissions target, given a range of post 2030 'uncertainty variants' with different assumptions that drive emissions prices and costs. The purpose is to explore which of the three starting scenarios is most robust to subsequent uncertainty.

The three pre-2030 scenarios are:

- Policy-driven: This includes a initial high emissions price and a government policy driven expansion of permanent native forestry in the land sector.
- Disruptive decarbonisation: features rapid technological change that disrupts current economic structures, with new technologies and products creating new

markets, destroying demand in traditional industries and accelerating capital turnover. Technological change occurs rapidly, driving the expansion of EVs and renewables.

- Stabilising decarbonisation; this scenario features optimistic expectations regarding the potential for rapid technological change that stabilises existing industry structures through the emergence of new mitigation options, such as methane vaccines and nitrogen.

This is a complex model, and it is difficult to judge whether it is delivering clear messages that are not artifacts of the construction of the scenarios or the structure of particular submodels.

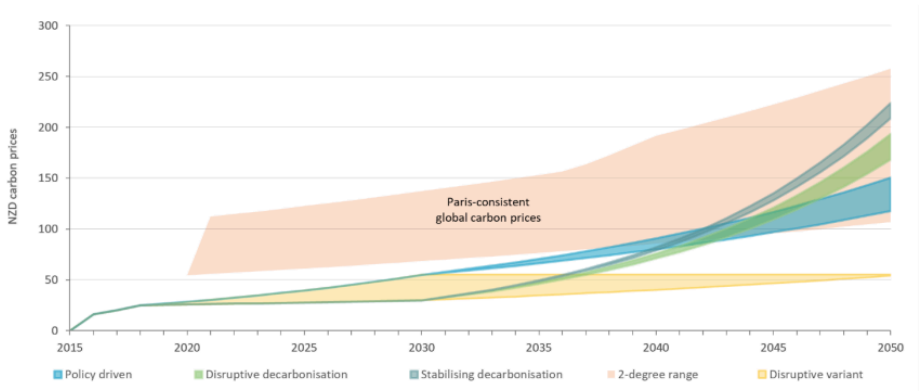
However, the paper comes to a number of conclusions, some of which might be contentious. In particular:

The Policy-driven scenarios deliver the lowest emissions price in 2050 in all uncertainty variants, suggesting benefits to stronger early action, as shown in Figure 1.

This conclusion has the appearance of a 'soundbite' for the MFE and the Productivity Commission. Figure one does show the policy-driven scenarios have lower 2050 carbon prices, but a lower carbon price at one point of time is not a very useful metric. It 'suggests' very little. What the paper should have compared is the present value of the cost paths for the scenarios presented in their figure 2 (above). We did a rough PV calculation and found that the disruptive technology scenrio was demonstrably superior (this is obvious from a visual inspection of the figure), while the destablising de-carbonisation and policy-driven scenarios were more or less equivalent.

Figure two: CMV carbon price tracks

Figure 1. **All scenarios, excluding Innovation-disrupting-existing-industry variants, see emissions prices within Paris envelope**

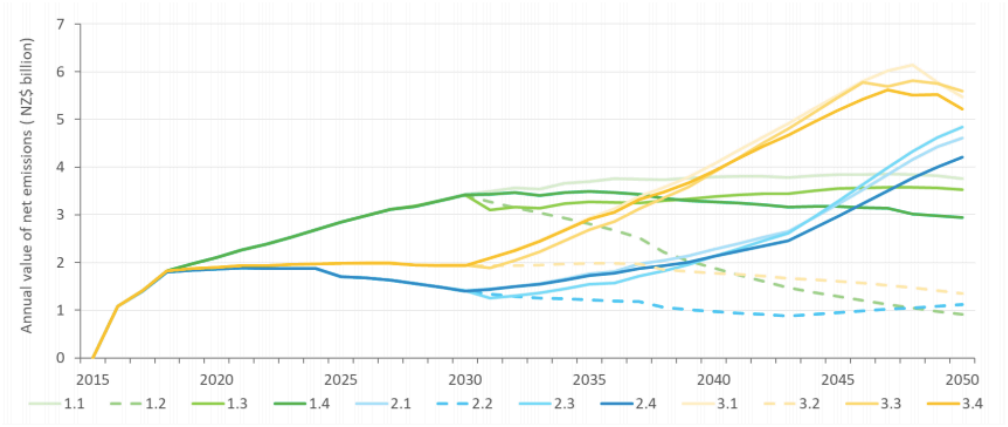


Note: *The innovation-disrupting-existing-industry variants for each scenario are presented separately in this figure (shown in yellow), as this variant sees the emissions-reduction target being achieved at prices far below Paris-consistent levels.*

Source: *Concept, Motu, Vivid Economics*

Figure three: CMV emission costs tracks

Figure 2. **Emissions costs stabilise after 2030 with early action, but rise given a slower start**



Source: *Concept, Motu, Vivid Economics*

Second.

The modelling results suggest that a portfolio of mitigation sources is beneficial, with broadbased policies providing incentives for low-cost emissions reductions across the economy

And

The scale of land-use change is modest in all future states of the world, but in some cases occurs rapidly.

These conclusions appears to be substantially driven by the way the land–use model is calibrated to generate forestry sequestations. It is assumed that forestry is relatively unresponsive to carbon prices. Only the present value of the first 10 years of carbon credits are counted when assessing the financial effect of the carbon credits on land-use decisions. Because new forests take some time to produce carbon credits, the 10 year cut-off ignores much of the economic value of the credits.

The assumption was carried over from the orginal Motu model [16], where it was justified by the financial risk born by carbon foresters, because of the uncertain price of the credits investors would have to repay when they harvested the forest. This problem has now been solved with the announcement of the average accounting option, which delivers lower initial carbon credits based on a long term level of carbon storage. The conservative assumption was also justified on policy uncertainty and price volatility grounds.

[16] Kerr et al. (2012).

The second type of risk has to do with policy uncertainty around the ETS, and arises in the years when owners are selling credits. It is possible that the scheme could be removed (or the value of credits could fall dramatically); forest owners would then receive little or no return for sequestration

These concerns did carry some weight back in 2012, but if the emissions targets mean anything at all, then surely the risks must be much lower now. The consultants were aware of the calibration issue but did not adjust the model.

Our methods potentially underestimate the carbon return to forestry under such a policy. However, there are some factors that reduce the magnitude of this error: these include the discounting of returns accruing in the future and the continued existence of risks associated with policy change, as well as the possibility that under the new rules the liability for deforestation might exceed the amount of credits earned.

These are weak excuses for doing nothing. Future returns, past 10 years, may be discounted but they will still be a significant. There will continue to be risks but they are less now than in 2012. And the Government could mitigate future price risks by entering into longer term purchase contracts with forest owners.

Further, carbon credits are already discounted by 8 percent in the model, which appears to be the industry rate for bearing the long term risk of production forestry output prices. This is probably sufficient to acccount for the carbon price risk.

A second pricing calibration issue is the treatment of native forest plantings.

Policy aspirations for native afforestation can be incorporated through the introduction of an exogenous parameter. This parameter controls the percentage of annual afforestation that goes to plantation forests versus permanent native forests. We assume that the policy intervention does not change the overall attractiveness of forestry land use, just the composition of planted.

We understand that one third of forests were assumed to be planted in natives. The effect of this assumption is to reduce the effectiveness of exotic forests in generating carbon units because natives grow more slowly than exotics. This has a double dividend for the MfE. A large number of more politically acceptable native forests appear, at no apparent cost, and forest sequestrations do not 'crowd out' the need for 'broad based' mitigation actions. Basically the model has been rigged to generate those results.

The CMV model is described as highly sensitive to commodity prices (carbon credits add to the price), and a more realistic carbon sequestation model would have seen more forestry, which would have to placed a lower cap on carbon prices.
The other thread to the early action argument is that if we leave forest sequestation late it will be difficult to meet the 2050 target because it will require forest conversions that are potentially well above historial peak levels. This concern is overstated. It costs about $1200-1400 a hectare to plant a forest, so the actual capital investment for, say, 200,000 hectares a year, would be $240 million. Many farms may change hands as part of the process, but that in economic terms this is a transfer that should be able to be handled by banking and capital markets. The real concern should be that exotic plantings will occur too early, and will provide limited offset benefits post 2050.

In '*The price of feeling good'* we did some ''back of the envelope' calculations to illustrate just how economically attractive carbon farming is at higher carbon prices. The relevant parts of the discussion are repeated below.

'We assumed:

- *No emission charge on farming so there is no avoided tax benefit.*
- *Establishment costs of $1500 per hectare.*
- *No carbon benefits for the first 5 years. It takes a while for growth to be material so this delay roughly accounts for this.*
- *The forest is not harvested, and there is no growth after 35 years. This is worse case scenario.*
- *A real discount rate of 5 percent, which is consistent with the 7 percent nominal rate often used to evaluate forestry investments.*

The results are set out in table 2.

Table two: Carbon prices and land valuues

Carbon price $/tone	**Land value per hectare $**
25	3650
50	8800
75	14000
100	19300
150	29500
200	39800

300	60500
800	164000

Recent farmland sales indicate that a typical per hectare price for sheep and beef farms is around $6000 – $8000. The above valuation figures suggest that there could be significant conversions from sheep and beef once the price gets to around $75. For more marginal or wasteland, conversions may become attractive at $50 or lower. These figures would be lower if account was taken of the harvest value of the forests.

The second factor to consider is the impact of carbon pricing on farm profitability. Assuming greenhouse emissions of 8 tons a hectare for dairy[17], at $75 per tonne the cost per hectare would be $600, and the total cost $94000 for an average 156 hectare farm[18]. Emissions of 1.5 tonnes per hectare for sheep and beef would cost $112.5 per hectare, and $74000 for a 600 hectare farm. For sheep and beef this might be around half of average annual profits. Once, after 5 years, when the forest is generating carbon credits, the annual income from carbon farming would be $765,000. While the income stream will only last for 30 years it would be hard to resist.

Once we get to higher emission prices, conversions of sheep and beef farms become compelling. At $200 a sheep and beef farmer has an emissions bill of $180,000 and in most years has to pay to work. If he converts to forestry, in 5 years or so, he will have an income of $2,000,000 a year and can lead a life of leisure. Many dairy farmers would also be tempted to join the leisure class.

Population growth

The CMV modelling also presents a sensitivity analysis that tested the robustness of the outputs to higher rates of population growth. It is reported that reducing the assumed population growth rate from 1.3 percent to 0.8 percent lowers the 2050 carbon price by only $14. However, the world does not stop in 2050, and sequestaion resources will have to be shared with a larger population beyond that date. A longer term focus and a bigger drop in the population growth rate also need to be considered. A 0.5 percent fall in the popultion growth rate over the 30 years to 2050 reduces the population by only 14 percent compared to the benchmark level. A 1 percentage point fall over 55 years to 2075 reduces the population by 42 percent. This would have a much more pronounced efefct on the carbon price.

[17] Kerr et al. 2014

[18] LIC 2016

The NZIER modelling

First stage modelling

The first stage of the NZIER modelling, which was reported *in Our Climate,* suggested that the carbon prices required to meet the emission targets would be very high and the economic cost would be significant. However, the NZIER was using a weak economic model which did not adequately deal with the key agricultural and forestry sectors and the standard of reporting was low, so it was of limited value. For a more detailed discussion of the modelling see 'The price of feeling good'

Our main takeout from the first stage modelling was that it showed just how far the MfE was prepared to go to manipulate the results to support its preferred option of a zero emissions target over the more moderate zero carbon target.

The reported marginal impact on the growth rate was lower for the tougher zero total emissions target target than the zero carbon target. This didn't make sense. The lower cost emission improvements would occur first, so the additional reductions under the tougher target should have had a higher cost.

Explaining the manipulation

The main explanation for this perverse result was the NZIER's arbitrary assumptions about the contributions of forest plantings for different targets. The 50 percent target scenario (roughly equivalent to zero net carbon) was assigned 25 million tonnes of what was a free good (more forests did not reduce agricultural production). The 100 percent scenario got 50 million tonnes. There was, obviously, no reason to restrict access to a free good for the 50 percent scenario. The only purpose was to 'fix' the results to make the zero emissions target look better.

The second part of the manipulation was to compare the policy outcomes to what was described as the 'status quo', rather than the current level of emissions. The 'logic' was that the previous government has already 'signed up' to a 50 percent carbon target. So 50 percent is a done deal and the economic cost of achieving that target could be ignored. it is only the additional changes that matter. This is disingenuous. The economic cost of achieving the target is the total cost. It doesn't matter when it was decided to meet the different components of the now current target. It the MFE's approach was legitimate then a government could announce a series of targets for a policy change and then only count the incremental cost of the last in the series.

The NZIER second stage modelling

In its second stage modelling the NZIER made several adjusments to its model

- Increasing forestry now reduced the amount of land available for agriculture.

- More favourable innovation assumptions were adopted, including the assumption that 80 percent of the light vehicle fleet would be electric by 2050. It was assumed that this could be achieved at no cost. More favourable innovation reduces the cost of the policies.

Forestry sequestions were still set exogenously.
Through an iterative process, we first determined that for a Net Zero all gases target, a sequestration level of 30 MtCO2e was appropriate, given our innovation assumptions. We then pro-rated this 30 MtCO2e sequestration down across the other scenarios, broadly based on the size of the required gross emissions reduction to hit the specific target.

There is no discussion of why 30MtCo2 is 'appropriate' or why the sequestaions were pro-rated down for the less demanding targets. The NZIER were simply directed to do so by the MfE. In the Peer Review of the NZIER modelling one of the criteria was that the NZIER performed the tests specified by the MfE.

The NZIER report does have a discussion of why its model produces much higher carbon prices than the CMV modelling. The key reason was that forestry sequestations were higher in the CMV model. The NZIER said that ideally you would want to line up with the CMV results, but that this was not possible because of the 'different modelling processes'. This is a rather lame excuse. The input is exogenous so the NZIER could easily have roughly have lined up with the CMV numbers. The real reason was that the MfE didn't want to have too much forestry, because of its political sensitivity, and because they want to promote a 'broad' approach to emissions mitigation.

Similarly, there is no discussion of why it was assumed that 80 percent of the light vehicle fleet was electric by 2050. This assumption is critical to the analysis as vehicle emissions are a significant part of New Zealand's overall carbon emissions, but there is no sensitivity analysis of less optimistic assumptions.

The NZIER sequestation 'methodology' allows the inputs to be manipulated to dampen the effects and costs of stronger targets. The standard assumption was 16 MtCo2e, but 22.6 was used for BF-50 (a 50 percent reduction for shortlived emissions) and 18.9 for BF-75 (a 25 percent reduction).

The impact of a 10 MCO2e increase in sequestations on 2050 GDP was estimated at $7.2 billion, so setting the sequestations at a consistent 16MCO2e would have increased the losses by $4.8 bilion and $2.1 billion respectively.

No competitiveness impact

On competitive impacts the NZIER says that these have been ignored.

As in Stage 1 it is assumed that all other countries take comparable action to New Zealand in reducing their emissions. If this occurs, then we would not expect any material impacts on New Zealand's export competitiveness, as our competitors would also be facing the costs of their emissions.

This is mostly wromg. Most countries are on carbon intensity targets, which will not impact in the same way as the New Zealand targets, and many of the committments are little more than hot air. In the agricultural sector there is little evidence that other countries are taking any substantive actions, so there will be some competitiveness effect.

The results

The results are presented both in terms of differences from the 'status quo' and, more legimately, from the baseline. An array of results are presented, none of which precisely match the emissions targets in the Bill. The closest match is an average of BF-50 and BF-75. The most relevant output in terms of the economic costs is the impact on the average real GNDI per household in the right hand column of the NZIER's results presented below. This cost is about $11500 per household. Adjusting for sequatation differences takes this to around $13000.

By contrast the comperable cost compared to the 'status quo' is around $6000. In its reporting of the results in the RIS, the MfE only reports the difference from status quo results. Half of the costs simply disappeared.

Figure four: NZIER results table baseline

Table 8 Headline results – differences from baseline

	Difference from the baseline in:				
Scenario	**Average real GDP growth 2020 2050 (CAGR)**	**Average real GDP level 2020 2050, $m**	**Real GDP, 2050, $m**	**Average carbon price 2020 2050**	**Average real GNDI per household 2020 2050, $000s**
SQ - Mod	-0.09%	-$10,286	-$14,489	$115	-$6.5
A – Mod	-0.57%	-$29,041	-$83,119	$1,125	-$17.9
B – NF – 50	-0.42%	-$22,525	-$63,518	$978	-$14.0
B – NF – 75	-0.40%	-$20,154	-$59,904	$1,039	-$12.5
B – F – 50	-0.27%	-$21,955	-$42,099	$518	-$13.7
B – F – 75	-0.16%	-$14,985	-$24,769	$271	-$9.4
C - Wide (30Mt)	-0.44%	-$28,662	-$65,767	$1,056	-$17.8
C - Wide (40Mt)	-0.12%	-$11,199	-$18,989	$406	-$7.1
*C-Wide-80%-Int-$150 **	*-0.20%*	*-$15,944*	*-$31,192*	*$567*	*-$10.0*

*Recall that in this scenario, we get to 80% of net zero all gases. The remaining 20% of emissions is offset through international purchases, at an additional cost to businesses of $2.08 billion between 2020 and 2050. Therefore the GDP and GNDI costs will be larger than reported in the table, as this additional cost is effectively an increase in imports. The average carbon price would reduce as the cost of international units is lower than the modelled carbon price.

Source: NZIER

Figure five: NZIER results table 'status quo'

Table 9 Headline results – differences from status quo

	Difference from the status quo in:				
Scenario	**Average real GDP growth 2020 2050**	**Average real GDP level 2020 2050, $m**	**Real GDP, 2050, $m**	**Average carbon price 2020 2050**	**Average real GNDI per household 2020 2050, $000s**
A – Mod	-0.48%	-$18,755	-$68,630	$1,010	-$11.5
B – NF – 50	-0.33%	-$12,238	-$49,029	$863	-$7.5
B – NF – 75	-0.31%	-$9,868	-$45,415	$924	-$6.0
B – F – 50	-0.18%	-$11,668	-$27,610	$403	-$7.2
B – F – 75	-0.07%	-$4,699	-$10,281	$156	-$2.9
C - Wide (30Mt)	-0.35%	-$18,375	-$51,278	$940	-$11.4
C - Wide (40Mt)	-0.03%	-$913	-$4,500	$290	-$0.6
*C-Wide-80%-Int-$150 **	*-0.11%*	*-$5,657*	*-$16,703*	*$452*	*-$3.6*

* Recall that in this scenario, we get to 80% of net zero all gases. The remaining 20% of emissions is offset through international purchases, at an additional cost to businesses of $2.08 billion between 2020 and 2050. Therefore the GDP and GNDI costs will be larger than reported in the table, as this additional cost is effectively an increase in imports. The average carbon price would reduce as the cost of international units is lower than the modelled carbon price.

Source: NZIER

Peer review of the Stage two modelling

The MfE commissioned peer review of the NZIER second stage modelling made the following statement.

Some assumptions in the analysis likely result in the emission reduction costs being overestimated, while other assumptions result in the cost being underestimated. On one hand, innovations that lower emissions – energy efficiency improvements above long run trends, increased penetration of renewable electricity, increased use of electric vehicles, and the methane vaccine – are assumed to come at no cost, which may result in costs being underestimated.

On the other hand, the model has limited scope for producers to reduce the emissions intensity of output, which may result in costs being overestimated. On balance, the costs of meeting emission targets estimated by the study are likely in the high end of the probable range.

There was no real basis for making this 'on balance' assessment. But it was helpful to the MfE in downplaying the significance of the NZIER economic cost assessments. If the reviewer had read the MfE's commissioned report on innovation by New Zealand industry (reported below) in response to energy price increases, they may have come to a different view.

Downplaying the results

In the RIS the MfE further tries to downplay the significance of the negative economic results. The modelling

- *presupposes that New Zealand's growth rate would be unaffected if the rest of the world acts and New Zealand does not*

It is not explained how New Zealand's growth rate would be affected. Presumably the MfE is referring to some kind of 'free rider' reputational impact. This risk could be mitigated by a less ambitious target and some hot air policy pronouncements. On the other hand there are more credible potential costs If New Zealand acts ambitiously and the rest of the world does not. As noted above this cost was not addressed in the modelling.

- *does not take into account the potential cost of damage a changing climate could cause to the economy*

This is irrelevant. Nothing New Zealand does will affect the 'damage' a changing climate will cause to the economy. In any event the best evidence suggests a small positive impact in the perod to 2050.

- *does not quantify the potential upsides of a stronger target, including faster innovation and wider co-benefits.*

These upsides are discussed in parts six and seven. There are very limited upsides.

Parliamentary Commissioner for the Environment's Modelling

The Parliamantary Commissioner for the Environment has also commissioned some economic modelling. The context was to support the Commissioner's prefered approach to emissions reductions.[19]

He argues that agriculture should be bought into ETS and that forest sequestation offsets should be restricted to the agricultural sector. The effect is to establish two emmision markets with different prices. The modelling is extended out to 2075, an improvement on the earlier CMV and NZIER which stops in 2050.

Under the split markets model the non-agricultural emissions price increases from todays $25 today, to $350 compared to $203 with a single market model. The biological emssions price is between $48 and $141 depending on the emissions target. These results understate the difference in the prices. It is assumed that 20 percent of emissions can be met with foreign units under the split model and only 10 percent under the existing model. Possibly the reason for imposing these different assumptions is that it makes the split model look better. It appears that the Commisioner has cheated a little here, which is disappointing. If you can't trust the Parliamentary Commissioner for the Environment then you can you trust?

The split policy makes little difference to the emissions outcomes. Residual emissions will still 6 million tonnes in 2075 compared to 4.3 million tonnes under the split target. This improvement would be brought at a heavy price. The marginal cost of abatement increases from $203, possiblly to well over $400.

[19] Parliamentary Commisioner fot the Environment 2019 'Farms, forests and fossil fuels: The next great landscape transformation?

Part five: The case for early action

Setting targets for 2050 is only part of the story. Equally as important is the speed at which we get there. On the face of we should be proceeding cautiously.

- One of the (few) robust results from the economic modelling is that the costs will depend on innovation, most of which is outside New Zealand's control. But we know that low carbon solutions will get cheaper, so in most cases it will not make sense to do things now that will be much less costly later on. A new electric car may cost $1000-2000 per tonne of carbon saved now, but hopefully, nothing in twenty years time.
- Getting too far out in front, increases the risk of damaging trade diversion, which will be economically costly, and may actually lead to an increase in emissions on a global basis.

However, the 'official line' is that there are benefits to strong early action. There are several threads to the argument.

1. It may actually lower the cost of transitioning to a low emissions economy.
2. It will enhance our role as a global leader in the fight against climate change.
3. We will secure the co-benefits of climate change mitigation earlier.
4. We will get a 'first mover' advantage through emissions mitigation innovation.

1. Lower transition costs

In its report the Productivity Commission leveraged off the second stage CMV, analysis we discussed above. The conclusion that early action would reduce the costs of transition was dubious, to say the least, but the Commission makes the most of it.

It is a form of societal insurance against slow technological progress and provides options if faster emissions reductions turn out to be needed to keep warming to a safe level;

It does not provide protection against slow technological progress. That insurance is provided by forest sequestation that will effectively put a cap on emissions. All early adoption will achieve is to disappate those resources making the post 2050 situation more costly, if technology continues to disappoint. The CMV analysis ignored post 2050 costs.

yield outcomes that achieve lower cumulative emissions to 2050;

Cumulative emmissions is not the primary target, but even if it was the Commission does not have regard to the cost of achieving those lower emissions. The actual difference in cumullative emissions between the scenarios are as follows:
Disruptive decarbonisation 1.5-1.6 GtCo2e
Policy driven (early action) 1.8 -1.9
Stabilising decarbonisation (slower action) 1.9-2.0
The difference between early and slower action is about 5 percent. This is mostly achieved by planting trees earlier, so there will be less capacity to plant trees later. There will only be a small impact on gross emissions over time.

provide the most protection against high-carbon investments that lock in emissions for many years into the future;

This is not really an additional argument. The lock in effect is already picked up by the cumulative emissions figures shown above. It is not explained which high-carbon investments will lock in emissions , and whether these are significant. Presumably they are referring to cars. At the current EV prices prices it is still efficient to purchase ICE cars, even with much higher future carbon prices.

promote an early start to expanding forestry which can then continue at a steady rate throughout the period to 2050, rather than face the challenge of having to plant at very rapid rates at the end of the period;

There is no point in getting an early start on plantings that will have little sequestation value post 2050, when sequestations may be much more valuable. As discussed above it is not much of a challenge to plant trees at a rapid rate post, say 2030.

create the space to devote a portion of new forestry to native species that grow and sequester carbon more slowly, yet which will continue to absorb CO2 well after 2050. Native species can also provide cultural and biodiversity benefits.

The opposite is possible true. A higher early carbon price will make exotic forestry more attactive, crowding out natives. Higher carbon prices increases the opportunity cost of more 'environmntally friendly' native plantings.

The benefits not built into the model are also very important

- *induce more low-emissions innovation which, as the modelling demonstrates, is crucially important to a transition with lower costs and higher benefits;*

It will not induce more technical change overseas, which is where most of the CMV model's innovation comes from. New Zealand innovation does not drive the model results.

insure against high future international carbon prices by reducing the need for New Zealand to make large future outlays to purchase international units to meet its emissions-reduction obligations.

The plan is not to rely on overseas units. Our best insurance is forestry sequestations.

give more impetus to moving away from path dependence on high-emissions technologies and economic structures – particularly when early higher emissions prices are combined with strong leadership on policy direction and institutional reform and government support for low-emissions innovation and investment.

This is not really an argument. Just a hopeful mantra.

The Westpac report

The MfE cites a report commisioned by Westpac, [20]which purports to show that including the farming sector in the emissions trading scheme early ,reduces the cost of getting to the emissions target. This report, by Ernest and Young and the Vivid consultancy is briefly reviwed in appendix one. The modelling was not well documented, but the results were not credible and appeared to have been contrived to produce the 'right' results.

2. Global leadership

'Global leadeship' is a key decision criterion in the RIS. While there is a case for meeting our global commitments, and not being a free rider, leadership is a step up, which implies, much stronger and earlier action. But the case for being a leadership is not really made in the RIS.

The Treasury on global leadership

The Treasury, in its review of the RIS makes the point.

The assumption is also made that a high level of ambition in New Zealand will bring reputational benefits and have a positive influence on other countries' mitigation efforts; and that this in turn will mitigate climate change to the point that New Zealand will experience further benefits, in terms of avoided adaptation costs.

[20] Westpac 2018

However, little evidence or argument is available to support that assumption. For example, it is emphasised that New Zealand's challenge in meeting its climate change obligations is different from that of other countries. This must reduce the likelihood that those other countries will want or need to follow New Zealand's example or to take advantage of any New Zealand technological innovations. This in turn weakens the logic that mitigation action by New Zealand will reduce the impacts of climate change experienced here. This creates significant uncertainty as to the benefits of the proposed action and it will be important to monitor progress.

Arguments for global leadership in the RIS

The only arguments advanced in the RIS are the following.

Influence on small emitters

However, small emitters collectively account for about a third of global emissions and, together, can have a significant impact..

The MfE does not say what it means by small emitters, but it appears that it includes all countries except the EU, the US, Japan, China, India and Russia (the big 6), which account for near 70 percent of total emissions. However, some of the 'small' emitters in the remaining 30 percent are actually pretty big (Brazil, Canada etc.) If we define 'small' emitters as countries with Co2 emissions of less than, say, 100 million tonnes, then these countries accounted for about 4.5 percent of global carbon emissions in 2017. Restricting the 'small' group to those with emissions of less than 50 million tonnes, reduces the share to less than 3 percent. So being an 'inspiration' to smaller countries will not make much of a difference.

In between the big six and the 'small' (less than 100 million tonnes) countries, are a group of 22 countries with combined emissions of 7.8 billion tonnes in 2017, up from 6.3 billion tonnes in 2005. Some of these are deveoped countries (Australia, Canada, Taiwan) with moderate emissions growth since 2005, but there were many developing and some richer countries (Saudi arabia, UAE) that increased their emissions by over 50 percent. The prospect of New Zealand influencing these countries must be close to nil.

Table three: CO2 emissions, million tonnes

Countries	**1990**	**2005**	**2017**	GDP per capita PPP $US
China	2397	6263	10877	
India	605	1211	2454	
EU	4409	4249	3548	
US	5086	5972	5107	

Japan	1149	1276	1320	
Russia	2380	1734	1765	
Indonesia	162	360	511	13200
Iran	207	468	671	17700
Malaysia	59	183	259	30900
Saudi Arabia	166	399	639	56000
UAE	57	122	203	89000
Turkey	150	245	421	28000
New Zealand	24	37	37	40000

Sources: IMF, EDGAR database

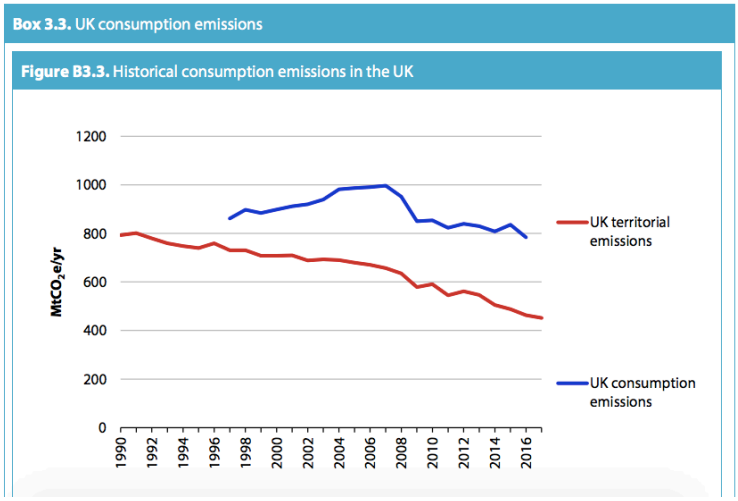
Atoning for a poor record

The second argument is that we have been 'backsliding', with the inference that a leadership role would somehow compensate for this.

Despite an overwhelmingly renewable electricity system and a sizeable forestry sector by international standards, New Zealand has among the highest per capita GHG emissions in the world. (NZ productivity commission 2018).

The Productivity Commission comparison used gross, not net emissions, so it excluded the forestry sector. The fairer comparison would be our emissions footprint, which would exclude our emissions intensive agricultural exports (and including emissions embedded in imports, which are less emissions intensive). Comparative international data are hard to come by, but our guess is that we are not a standout on a footprint basis. In this respect there is a useful figure in the UK Climate Committee's 2019 report on increasing the UKs climate mitigation ambitions to net zero. The fall in consumption emissions is not as impressive as the fall in territorial emissions, suggesting, perhaps, that the UK's polices may have generated some carbon leakage.

Figure six: UK emissions



The UK Climate Committee on 'fair shares'

The UK Climate Committee made a number of 'fair share' arguments in its report. These included: the UK's high income; its developed institutional framework; and its historical contribution to global carbon emissions. The UK has about 1 percent of the world's population, but is estimated to be responsible for 2-3 percent of cumulative historical emissions. New Zealand does not have as much of an industrial emissions legacy, and historical methane emissions will have largely dissipated. However, our deforestation legacy may be disproportionate to the populations responsible for it.

When Māori arrived, about 1250–1300 AD, they burnt large tracts of forest, mainly on the coasts and eastern sides of the two main islands. By the time European settlement began, around 1840, some 6.7 million hectares of forest had been destroyed and was replaced by short grassland, shrubland and fern land. Between 1840 and 2000, another 8 million hectares were cleared, mostly lowland or easily accessible conifer–broadleaf forest[21]

The Parliamentary Commissioner for the Environment

The Parliamentary Commissioner for the Environment makes a more focused argument on global leadership. He makes a case doing more in agriculture, not just in research but by including agriculture in the emissions scheme, presumably at an early date.

'more is likely to be expected of New Zealand in the one field where it is an acknowledged leader. To show real leadership, any gains made in research will have to be complemented by real emissions reductions from the agricultural sector.

[21] *New Zealand Encyclopedia on-line*

Being able to include agriculture in any targets and carbon budgets will be important evidence of the seriousness of New Zealand's contribution to a global problem.

Is is a reasonable argument, and perhap our leadership ambitions should stop there. An increased research contribution, and work on the non-trivial problem of reliably and economically measuring emissions at the farm level could be our special contribution.

New Zealand not a natural candidate to lead the world

It is generally accepted that the rich countries should take the lead in reducing greenhouse emissions. However, New Zealand is not really a rich country, sitting on the margin of being upper middle-income. By 2050 it is likely, we will have further slipped down the per capita income league table. A Country like Malaysia ,which have done nothing on climate change mitigation, will probably be richer than us. This weakens the case for New Zealand bearing a disproportionate share of the mitigation burden, particularly if the result is to push us more firmly into middle-income territory.

Many other countries are not doing as much as New Zealand

As an example, consider the case of Singapore. As a high-income country, which is directly in the climate change firing line, we might expect a sense of urgency and substantive actions. So what is Singapore doing?

First, it signed up to a fairly soft 'developing country' Paris agreement target, promising that their emissions will peak in 2030. To our knowledge they have made no commitments beyond that date. In terms of what they are actually doing, the main policy tool is a new carbon tax of S$ 5 per tonnes, affecting thirty to forty large companies, from 2019. Singapore will review the carbon tax rate by 2023, with plans to increase it to between $10 and $15 per tonne of GHG emissions by 2030.

In addition:

- 2018 was declared the year of climate action
- Singapore will host a special ASEAN Ministerial meeting on Climate change
- There will be some financing subsidies.

Being left high and dry

In the RIS the MfE recognises that there is a risk that the world will not meet its Paris commitments.

The world has committed under the Paris Agreement to resourcing and financing the global transition to low emissions. However, there remains the unlikely risk of New Zealand

incurring the significant costs of the transition unduly (and without any material impact on climate change) if the rest of the world does not act accordingly

This risk may be mitigated through concerted international engagement and cooperation in a range of bilateral, regional and multilateral fora, in which New Zealand may hold others to account by communicating its ambitious target and ongoing efforts to reduce emissions at home.

We wonder what representations have been made to the Singaporean to get them to mend their ways.

New Zealand's influence is naively overstated and increases our risks. The plan apparently is to charge on regardless of evidence that other countries are not doing their share, in the hope that with an ever more determined New Zealand effort we will change their minds.

Part six: The co-benefits of climate change mitigation

The co-benefits of climate change mitigation are an important part of the MfE RIS assessment. It is claimed that the co-benefits are large, and it is implied that they offset much of the adverse direct economic effects of emission mitigation measures.

MfE's discussion of co-benefits appears in several papers. There are shorter discussions in the 'Our climate' and in the RIS; and a section on co-benefits in the document 'Zero Carbon Bill Economic Analysis: A synthesis of economic impacts. The detailed, comprehensive analysis is presented in 'The co-benefits of emissions reduction: An analysis' MFE 2018.

The synthesis document purports to capture the key takeouts from the main co-benefit document. It identifies

five key areas where wider co-benefits are foreseen to be substantial with action to reduce emissions and where there is sufficient evidence to support such claims.
They are :
1. Better home insulation could improve health.
2. Shifting road freight to rail could reduce congestion and maintenance costs.
3. Shifting to public transport could reduce congestion and improve road safety.
4. More walking and cycling could reduce congestion and improve health.
5. More forestry could improve water quality and biodiversity.

The evidence supporting this claim is set out in the main co-benefits paper.

The main co-benefit report

'*The co-benefits of emissions reduction An analysis'* is a lengthy document that covers almost every conceivable co-benefit from possible policies that might have an emissions reducing effect. To be fair to the authors of that report we have reviewed the complete document and set out as much of their arguments as space permits.

On the motivation for emphasing co-benefits
The review begins with the rationale for the focus on co-benefits. It is partially political.

According to IPCC (2014): Climate policy intersects with other societal goals creating the possibility of co-benefits or adverse side-effects. These intersections, if well-managed, can strengthen the basis for undertaking climate action. Bain (2016) shows that co-benefits can help motivate action, particularly in communities that did not see climate change action as important. This can be particularly successful if the actions can be linked to economic development or the creation of a more caring community.

And

Recognising co-benefits can help take a more holistic view of policy actions. They help link emissions reductions to other policy agendas, highlighting where there might be complementary outcomes (or clashes). Co-benefits can highlight policies that may not be important for the sole purpose of reducing emissions but rather for their holistic impact on well-being.

This might be fine if the co-benefit assessments are honest, competent and realistic. There is nothing to stop these co-benefits being taken into account in a standard cost benefit analysis of particular initiatives. The problem with this 'co-benefit as political driver' approach is that it intertwines issues that are largely separable, making it more difficult to understand the costs and benefits of specific climate

change initiatives. The risk is that a minor climate change impact can be enlisted to provide support for policy actions that on their own merits do not make much sense.

And this is what tends to occur in the review paper. The 'success metric' becomes the ratio of co-benefits to the value of the emissions reduced. The less effective the policy in reducing emissions, the higher the co-benefit to emissions ratio, for a given level of co-benefits, and the better the policy intervention. Bad policy becomes good policy.

Structure of the report

The report proceeds by looking at possible emission reduction policies and then for each policy objective, it describes :

• the intermediate pathways (ie, how the actions to reduce emissions will lead to other impacts)
• the actual co-benefits
• the scale of those co-benefits, both in absolute terms and relative to the emissions reductions
• the strength of evidence of co-benefits.

The Initiatives

Stronger emissions pricing

The review makes the argument that emission taxes could have positive effects.

A strong, long-term emissions price signal could not only contribute to the other policy objectives discussed later in this report, but could also raise revenue to reduce the distortionary impacts of other forms of taxation.

The concept has a strong grounding in economic theory, provided it is revenue-neutral, and therefore seems likely to have a positive though small impact.

This is correct as long as the emissions price is linked to the external costs of emissions. Otherwise, it could impose a consumption tax distortion.

Energy efficiency

Intermediate pathways

Appropriate insulation and ventilation of homes is a major factor in reducing cold, and houses that are cold are also more likely to be damp (Gillespie-Bennett et al, 2013). Insulation can improve temperatures and reduce dampness, particularly reducing exposure to extremely low temperatures in winter. As a result of insulation, self-reports of wheezing,

taking days off school or work and visits to the GP or hospital were reduced (Howden-Chapman et al, 2007).

Better domestic insulation generally does not reduce energy use. As the report admits, people tend to increase their heating temperature with better insulation. Further, the great majority of existing houses already have ceiling insulation and further improving insulation tends to be grossly uneconomic. Also, New Zealand homes are mostly heated with renewables, so even if energy use is reduced there will be little net impact on emissions.

Business energy efficiency improvements bring obvious and immediate benefits to profit, which are captured by standard economic analysis. However, there is evidence of potential knock-on benefits as well, with businesses that have made energy efficiency improvements becoming more likely to increase employment in the future (Metz et al, 2007).

We were unable to access the Metz reference, which was a contribution to the 2007 IPCC report. However, there does not appear to be any obvious causal link between energy efficiency improvements and employment growth. Probably the Metz paper was just picking up a correlation, not causation. It might also be picking up an inefficient use of labour in energy efficiency projects.

Energy efficiency, if applied at times of peak demand, can also reduce pressure on the electricity distribution network, reducing the need for additional investment (this concept is discussed in detail under the demand management section below).

This is an argument for efficient peak time pricing rather than a co-benefit as such.

Co-benefits
The potential health co-benefits of improved home insulation are significant. New Zealand has one of the highest rates of asthma in the world, with one in six adults affected, at a total estimated cost of $800 million per annum. This is likely to be linked to our poor standard of housing; one-third of New Zealand homes remain uninsulated (Holt & Beasley, 2001; Gillespie et al, 2013).

As noted above the link between emissions and home insulation is misconceived. In any event the casual link between asthma and housing insulation is unproven. The best analysis on the matter was a study that cited in the Healthy Homes RIS, which looked at early childhood wheezing. It found that there was no difference in the insulation of the homes of children with wheezing and a control group where the children did not have wheezing symptoms.

On the number of uninsulated houses, the Holt and Beasley paper is obviously out of date, and the reference to one third of uninsulated houses in Gillespie et al was an unsupported assertion, which was almost certainly an exaggeration.

The 2015 House Condition Survey showed 830,000 houses in New Zealand have sub-optimal roof insulation and/or sub-floor insulation (White & Jones, 2017).

The 'suboptimal' reference is to the fact that not all houses meet the current new house insulation standard. Retrofitting ceiling insulation to the current standard increases the effectiveness of the insulation by only around 8 percent[22] Topping up to meeting the current standard has a low benefit/cost ratio and is not an 'optimal' intervention.

Those living in the poorest quality housing could see their respiratory problems fall by one third if their housing improved (Gillespie-Bennett et al, 2013).

This is another general, unsubstantiated assertion, which has little to do with emissions reductions.

There are also an estimated 1600 additional deaths each winter that may be attributed to the impact of cold (Davie et al, 2007).

Every country has excess winter deaths, partially due to the higher incidence of chest infections in those periods. A co-benefit of a warming climate is that excess winter deaths may fall.

Scale of co-benefits
The benefit-cost ratio of insulating previously uninsulated houses is estimated at 4:1 generally and even higher for at-risk groups (children and the elderly). The bulk of this benefit comes from the health gains, rather than emissions reductions, as most people choose to maintain (or even increase) energy use and have a warmer house (Grimes et al, 2012). On average across all newly insulated homes, the relative health co-benefits are far higher than the emissions reductions benefits.

The cost benefit analysis of 4:1 in the Grimes study of the warm-up New Zealand insulation program was overstated and the true figure is almost certainly less than 1.

- Only half of the costs of insulation were counted, because the labour cost element was ignored. This is not legitimate.
- The NZIER[23] reviewed the analysis and concluded that the value of a life saved was overstated by a factor of three.

[22] Cabinet paper for Healthy Homes

[23] Economic Analysis of the healthy homes initiative.

- Most of the benefits were from avoided deaths. But the lower death rate was entirely concentrated amongst occupants who where over 65 and who had previously been hospitalised for a cardiovascular condition (less than 3 percent of the study population). There was no life saving benefit for the rest of the population. The policy conclusion that should have been drawn from the study is that insulation should have been restricted to houses with already sick elderly occupants.
- The Warmup New Zealand study was not a controlled randomised trial, so it is possible that the life saving benefit could be explained by differences in the behavioral characteristics of insulating and non-insulating households.

Energy efficiency

Concept Consulting (2017) has estimated potential present value benefits of $480 million from a $140 million investment in energy efficiency. Of those benefits, $60 million are emissions reductions, $100 million comes from lower spending on generating power and $280 million comes from lower investment on electricity distribution and generation infrastructure. This is predicated on the energy efficiencies being realised during peak times, thereby reducing the pressure on the electricity distribution infrastructure (see the demand management section
below).

The Concept Consulting report is a pitch, by the Energy Efficiency Authority for the case for promoting energy efficiency. The positive outcomes depend on a number of assumptions, including the costs of making the required changes, which are not well documented. We could not assess the robustness of the $60 million emissions reduction estimate. Again, while energy efficiency might be a worthy objective on economics grounds, it has a limited role in reducing emissions when the energy is generated with renewables.

Strength of evidence
The evidence of health co-benefits from improved insulation is strong, as is the potential for infrastructure savings, although this is predicated on the efficiencies being realised at peak time.

In our view the evidence on health co-benefits is weak and will become increasing irrelevant as electricity generation becomes increasingly renewable.

Renewable electricity

This section looks at the co-benefits from actions to increase the proportion of electricity generated by renewable sources. There may be some health and possibly employment cobenefits from this.

Intermediate pathways

A possible co-benefit of renewable electricity generation displacing fossil fuel electricity generation is reduced air pollution. However, this depends on the type of renewable generation and the type of fossil fuel it is displacing. There are air quality impacts from geothermal and biomass-based electricity generation (even though they are renewable), so we cannot make any definitive statements here.

For employment, the labour intensity of renewable energy jobs in Poland has been estimated at 10 times higher than that of traditional coal power (Metz et al, 2007). This calculation is heavily based on local economic characteristics and cannot be readily generalised to the New Zealand context without further work.

The idea that more employment in a particular sector is inherently desirable is based on the 'circular economy' premise that the amount of labour used is a benefit rather than a cost. In this view of the world time has no opportunity cost. But generally it is economically costly to employ 10 people to do the work of one.

Health Co-benefits from emissions reductions

High health co-benefits from emissions reductions is a critical part of the MfE narrative and we examine MfE's evidence at length.

Air pollution from human activity is estimated to cause around 1000 premature deaths per year. The total cost of deaths related to air pollution is estimated at $4.28 billion per year (Kuschel et al, 2012).

A cost of $4.28 billion per year is a big number and if a significant part of that can be reduced by emission reduction initiatives it provides support to the co-benefit narrative.

The source on the health cost figure is the 'Updated health and air pollution in New Zealand' (HAPINZ) study (2012). However, the MfE notes that the $4.28 billion is likely to be an overestimate.

- The methodology is different from other estimates created for the Global Burden of Disease study (Ministry of Health, 2016). Using a like-for-like methodology reduces the estimate for air pollution deaths from 1000 to 570.
- The HAPINZ update study valued a death at $3.5 million, which was the figure used to value the cost of traffic accident deaths. The previous HAPINZ study used a figure of $750,000. Because air quality primarily causes deaths in old age, it was assumed that only 5 years of life would be lost. The Update, on the other hand, assumed that all deaths should be valued equally, regardless of age. The social cost of a death at 20 years of age, with the loss of 60 future years of life, is the same as a death at 85 with the loss of, say, 2 years of life.

This is not a judgment we share and we did not see any convincing arguments in the Update to justify it. The MfE was also, apparently, uncomfortable with it. Using the previous methodology reduces the value of the benefits by a factor of 4.5.

Adjusting for the number and value of lives lost reduced the annual cost to around $550 million. The MfE was aware that $550 million was the more credible total estimate and should not have repeatly cited the $4.28 billion estimate through their review.

The next issue is the amount of air pollution attributable to emissions that contribute to climate change. In the HAPINZ report 22 percent of emissions were attributable to motor vehicles and 10 percent to industrial processes. The biggest source is domestic emissions, but this is almost entirely from renewable wood, which is not the target of climate emissions policy. So at most only a third of emissions costs can be identified as an emissions reduction co-benefit. This would bring down the annual cost to about $180 million.

The MfE tried to duck this issue by repeatedly claiming that it is 'difficult' to attribute emissions to their source. The information is readily available in recent MfE and Statistics New Zealand reports. The real reason for ignoring this information, we believe, is that the MfE didn't want to dilute the 'big headline number' effect.

Impact of emmisions on excess deaths

The most important issue is the yawing gap between the HAPINZ airpollution death estimates and those reported by the World Health Organization in their paper '*Ambient air pollution: A global assessment of exposures and burden of disease' 2016.* The study found that New Zealand had the equal first best air quality in the world, and that the number of deaths from all human sources in 2012 was **20.** The death rate per 100,000 people was 0.5 compared to the HAPINZ estimate of about 25.

The MfE must have been aware of this divergence and should not have used the HAPINZ results unless it was confident that the underlying science was robust. Looking at the HAPINZ analysis we identified a number of issues.

- Deaths are estimated to increase by 7 percent per 10 mg. M3 increase in air particulates. But hospital admissions for illness classes related to pollution, increased by less than 1 percent. This difference should have raised some questions about the reliability of the mortality results.
- The HAPINZ estimate was based on a single New Zealand study (Hales 2010).

The Hales analysis was not based on actual measures of air pollution. Instead air pollution was modelled from estimates of source emissions, using a model calibrated from just Christchurch's measured and modelled levels of pollution. This might have biased the results. Christchurch is not a 'normal' New Zealand city from a pollution perspective. It is admitted, by Hales, that this approach will, at the least, have narrowed the confidence interval, around the central estimate, but the question of bias was not addressed.

- The modelled emissions by city or town are not used directly. Rather they are aggregated into four groups, suppressing variability, and further narrowing the confidence interval. As the confidence interval was already 1.03-1.10 around the central of 1.07, it is possible that a more robust approach would not have shown a statistically significant relationship between mortality and pollution levels.
- The Hales study was not independently reviewed for the HAPINZ report. The section (appendix 3) on health outcomes and the exposure –response relationships was prepared by Hales. This breached a basic rule for the use of science in policy development.
- Finally, it was just assumed that there was no threshold effect. That is, even the smallest amount of air pollution was assumed to have a mortality effect. The explanation was that *'this is in line with current thinking for exposures in the range typically experienced in New Zealand',* and two references (Schwartz et al. 2002, Schwartz et al, 2008) were cited in support. The absence of a threshold might have been in line with the report authors' own thinking, but this is not an argument. The 2008 Schwatz paper was a response to a decision by the U.S. Environmental Protection Agency (EPA) not to tighten the annual average standard for particles (15 µg/m)[24]. The EPA argued that there is no convincing evidence for effects below that level (U.S. EPA 2006). Schwatz presents a study that comes to a contrary view. But that is only one opinion, and looking at the study, the confidence intervals for the low exposure levels prevalent in New Zealand were broad (not significantly different from zero) suggesting that the US EPA was right, at least for New Zealand.

In a 2015 report[25] the Parliamentary Commisioner for the Environment raised some questions about the robustness of the New Zealand cost of air pollution estimates, though without going as deeply as we did into the underlying analysis. She posed the

[24] The New Zealand averge is under 10, with Christchurch at 17 the only significant urban area exceeding that limit.

[25] Parliamentary Commissioner for the Environment. 2015. The state of air quality in New Zealand Commentary by the Parliamentary Commissioner for the Environment on the 2014 Air Domain Report.

question: why, with similar air quality Australian premature death estimates were only fifty percent larger than New Zealand's despite the Australian population being five times larger. The Commissioner's report was ignored.

To conclude, the New Zealand evidence is not very robust, which suggests that the airpollution co-benefit is significantly lower than $180 million. On the WHO figures it would be less than $10 million. This is along way from the MfE's headline number of $4.28 billion.

Electric vehicles

The shift to electric vehicles will have a large impact on reducing emissions, but there will also be co-benefits for health of a comparable scale.

As demonstated above the health benefits are relatively small, and will be a small fraction of the emission reduction benefits.

Electric vehicles also have lower levels of noise than the standard internal combustion engine. Noise pollution is the most frequent complaint to local councils under the Resource Management Act.

This does not mean that noise from motor vehicles is a frequent complaint.

Energy security

There may also be benefits from increased fuel security from a shift to electric vehicles. Currently, New Zealand imports most of its transport fuel, but the electricity to power electric vehicles would be provided locally. This could potentially insulate the New Zealand economy from the costs of a spike in oil prices.

However, it is concluded that the net effect is speculaltive because renewable energy depenency raises its own security issues.

Noise pollution is estimated to cost the European Union about €40 billion each year, roughly 0.4 per cent of its GDP (den Boer & Schroten, 2007). No estimates are available for New Zealand.

A consultants report commissioned by the Productivity Commission has produced a New Zealand figure, but it was relatively small. The costs in den Boer & Schroten, study were largely driven by an estimate of Europe wide deaths due to heart attacks caused by traffic noise, of 50,000. Without getting into the detail, we found the study to be dubious. Electric cars will still make road noise (some countries are requiring them to generate an artificial engine noise for safety reasons) so we wouldn't expect there to be much of an impact on genuinely harmful noise pollution.

Boy racers, will find it more difficult to raise a racket with an EV, but the boy racer 'problem' is localised, and while being annoying probably doesn't impose a material health risk to the general population. They will still have boom boxes which will operte in an EV.

Strength of evidence
The strength of evidence is moderate. The quality of air pollution data and the resulting health impacts are reasonable, but it is difficult to attribute these to different sources. Fuel security, noise and water pollution benefits are more speculative.

Freight to rail
Putting more freight onto the rail network would reduce the amount of trucks on the road, leaving greater space for other road users.

This would be particularly valuable in congested areas of the network; for example, during peak travel times in cities. Road users currently do not pay for the congestion costs they create, and freight carriers are no exception. Freight users pay for the average costs of their wear and tear on roads through road user charges (RUCs). However, this does not account for the marginal wear and tear generated, as increase in road freight compounds the problem.

There is no analysis of the contribution long distance freight could makes to peak travel times. Freight still has to be shifted from the freight yard to the final destination, so there may not be any benefit, let alone a material benefit. If road freight is not paying its fair share of road maintenance then this is an argument for adjusting road user charges.

Carrying freight by road also increase the risk and cost of accidents. Trucks are generally safer than passenger vehicles, but accidents involving trucks have far higher rates of death and serious injury (EY, 2016). The costs of accidents are not fully internalised into ACC levies, particularly in the case of death.

If the later point is correct it can readily be addressed by adjusting the ACC levy, or where this is not appropriate the road user change.

Co-benefits
Traffic congestion costs households and businesses in Auckland an estimated $0.9-$1.3 billion every year in lost time and economic activity (New Zealand Institute of Economic Research, 2017).

Carbon emissions are not really the issue here. There would be the same problem with electric cars or hydrogen fueled trucks. Indeed electric cars could exacerbate

congestion problems because they have a low marginal running cost, which will encourage more usage.

Around 23 per cent of the $4 billion spent annually on our roads goes on maintenance. Road freight is likely to cause the bulk of wear and tear on the main routes they traverse. The road toll in 2017 was 380 deaths and injury numbers have ranged from 11,000 to 13,000 per year over the past few years. The social cost per life saved is $4.14 million (Ministry of Transport, 2017).

These are just more examples of the MfE just spraying statistics around with little regard to the issue, which is how particular rail freight proposals will help.

Scale of co-benefits
The degree to which it is possible to switch from road freight to rail in New Zealand is not fully known. However, Ernst and Young (2016) gives an idea of the relative scale of co-benefits based on the current levels of freight use in the rail network.

The largest benefit from the current rail freight service comes in reduced congestion on the roads, valued at between $200-208 million per year. Next comes maintenance benefits of $77- 80 million, followed by safety benefits of $56-61 million. The total emissions reduction benefit is around $6 million That number could increase slightly with increased electrification, but these other co-benefits are likely to continue to dominate.

This information is mostly irrelevant. It is not a question of closing down the existing network, but of assessing the value of changes at the margin.

Strength of evidence
The strength of evidence is moderate. It is clear the co-benefits are large compared to the emissions reductions benefits, although the scope for increased transport of freight by rail is unclear.

No relevant evidence is presented for the value of either the emission reductions or the co-benefits.

Public transport
While increasing the use of electric vehicles is often the focus of emissions reductions in New Zealand's transport sector, the potential for co-benefits are far higher through increasing use of both public and active transport.

Intermediate pathways
Increased use of public transport means fewer vehicle kilometres travelled in private cars. Switching modes from private cars to public transport reduces congestion and saves considerable space in cities. Public transport is able to hold 27 times more passengers per

square metre of road occupied, including parking (Litman, 2015). This will also reduce costs associated with building infrastructure and create benefits in time saved.

Again this is a mainly a congestion issue not a climate change mitigation issue. Electric cars are just as congesting as ICE cars.

Public transport is safer than a private vehicle. The risk of being killed or injured as a passenger in a bus is seven times lower than for driving a car and four times lower for being a passenger in a car per kilometre travelled (Ministry of Transport, 2015). Public transport uses fuel more efficiently than private transport, which reduces air pollution There is evidence overseas that increased use of public transport over private vehicles increases exercise, resulting in health benefits (Martin et al, 2015).

Most public transport is a substitute for trips to work. Trips to work have a lower death rate for car travel than open road travel, so the MOT figures are not directly applicable. Public transport use also requires some walking, which is more than five times riskier than travelling by car.

The Martin study looked at the effect on body mass indexes (BMI) from switching from private vehicle use to public transport and active transport. While there was a fall in the BMI when a combination of active and public transport were considered (the headline reporting in the abstract), there was no statistically significant impact from the switch from private transport to public transport. The MfE should have read the entire study.

Co-benefits
The major co-benefits of a switch to public transport are reduced congestion, better safety and improved air quality respectively. Traffic congestion costs households and businesses in Auckland an estimated $0.9-$1.3 billion every year in lost time and economic activity (NZIER, 2017). The road toll in 2017 was 380 deaths and injury numbers have ranged from 11,000 to 13,000 per year over the past few years. The social cost per life saved is $4.14 million (Ministry of Transport, 2017).

None of the above information is relevant to a consideration of the marginal benefits and costs of switches to public transport.

Scale of co-benefits
The scope for increased use of public transport as a result of cost effective investment in New Zealand is not known.

However, Ernst and Young (2016) estimates the total value of the existing passenger rail network in Auckland and Wellington is between $1.132-1.183 billion, of which, reduced

congestion generates almost all the benefits. Safety benefits from a mode switch are likely to be small compared to the congestion impacts. The safety benefits of the Auckland and Wellington rail networks were less than one per cent of the total benefits. ***The benefits of emissions reductions were also less than one per cent of the total*** (our emphasis).

This supports our point that public transport is a congestion, not a climate mitigation issue. And to repeat, the value of the network is not relevant to the costs and benefits of changes at the margin.

Strength of evidence
The strength of evidence is moderate. The congestion benefits of public transport are large, but the potential for cost-effective investments to increase public transport use are not known.

If the scale of cost-effective public transport initiatives is not known then there is no basis for arguing that there will be large co-benefits.

Active transport
One of the MfE's biggest pitches is for active (walking, cycling) transport. Mostly this is an argument that active transport will make people healthier. This might be true, but whether people can be induced to do it, and whether the various proposals to encourage active transport make economic sense, is a different story. Mostly this is not a climate emission story. The realistic reduction in the level of transport emissions is very small (one percent), and in any case will fall with the electrification of car transport, and/or the widespread adoption of electric scooters (which have no health benefits and significant costs).

But we get a lengthy argument for the case for active transport (and by implication more investment), which we discuss here.

Increased use of active transport means fewer vehicle kilometres travelled in private cars. Switching modes from private cars to active transport saves considerable space in cities. Cycling takes up 1/18th of the space of cars, including roads and parking (Litman, 2015). As a result, the increased use of active transport reduces congestion, which in turn reduces costs associated with building infrastructure and creates benefits in time saved. Increase in active transport (e.g., walking and cycling) will lead to increase in exercise overall.

The Litman study is a pitch for 'optimal' urban development compared to urban sprawl. There is no direct analysis of active transport as such, but some small association between more compact cities and health outcomes are reported.

Active transport is unlikely to be offset by increased calorie intake or reductions in other forms of exercise. As a result, those people who use active transport are 76 per cent more likely to meet the minimum recommended guidelines for exercise (Shaw et al, 2017).

This might be true, but this does not tell us anything about the likelihood that those who do not use active transport can be induced to do so. The Shaw study also showed that people using public transport were no more likely to meet the minimum exercise recommendations than those who use private transport.

The heath risks of active transport is acknowledged but largely waived away.

…the Government has signaled increased investment in safer cycling and walking infrastructure to mitigate this. The rate at which cyclists are killed or injured decreases as overall cycling numbers rise, partly because of decreased use of cars (which endanger cyclists) but also because of 'safety in numbers'. As more cyclists take to the road, they are more noticed by drivers and hence become safer (Macmillan et al, 2014).

The 'safety in numbers hypothesis' might be logically possible, but MacMillan does not present any evidence to support this conjecture, and how likely it is that a 'safety threshold' will be reached.

Overall, the benefits of active transport remain positive. Longitudinal studies (ie, over time) have shown 'all-cause mortality' was 30 to 40 per cent lower in people who cycled compared to those who did not use active transport (Haines, 2012).

Haines references two studies to support this claim. We consider them in our discussion of the MacMillan study.

There is a strong link with demand management, as denser urban form and investment in infrastructure is key to encouraging the use of public and active transport (WHO 2009).

The urban form of New Zealand cities will not change materially over the relevant time frame.

A systematic review in the United Kingdom found (despite a variety of methods used) overwhelmingly positive benefit-cost ratios for investment in active transport interventions, with an average benefit-cost ratio of 5:1 (Cavill, 2008).

The main purpose of the Cavill paper was to assess the quality of papers reporting benefit/cost ratios for active transport measures. It found that the quality was generally low, with a lack of transparency on the methodologies. In particular, many relied on optimistic assumptions about the uptake of active transport. The benefit cost ratios were all over the place, with the ratios ranging from -0.4 to 32.5, with a

median of 5.1. This median figure doesn't mean anything in the absence of a careful consideration of the individual results. The MfE should not have used it.

Co-benefits
The largest co-benefit of active transport appears to be more people getting their recommended 'dose' of exercise. Around half of New Zealanders currently do not meet the recommended levels of exercise (Ministry of Health, 2016). According to the Global Burden of Disease study, low levels of physical activity caused 1079 premature deaths (3% of the total) and the loss of 14,000 disability adjusted life years in New Zealand during 2016 (1.32% of the total).

The Ministry of Health estimates tell us that insufficient exercise is not a major cause of losses disability adjusted life years, but the figure overstates the potential for active transport to make a difference. DALY's are disproportionately borne by the elderly, who do not work. There are many other forms of exercise that may be more effective for the target groups than cycling to work. Cycle lanes are unlikely to be a health intervention priority, if health promotional funding was allocated rationally.

A large-scale switch to active transport could potentially avert almost all of these negative impacts. A complete shift in modes is unlikely, but even bringing other New Zealand cities up to the levels of public and active transport seen in Wellington (27.5% of trips by walking and 1.3% by bike) would create considerable benefits for both health and congestion (Shaw et al 2018).

It might, but wishing it were so, doesn't make it so.

Macmillan et al (2014) go further showing best practice investments in Auckland's cycling infrastructure could give a high return on investment (between 6 and 25 times the investment required) and results in levels of cycling seen in Europe (40% of trips by 2050).

Scale of co-benefits
The absolute scale of benefits depends on the scale of the mode shift. Given current levels of investment in active transport, Macmillan et al (2014) estimate the business as usual mode shares for cycling and light vehicles at five per cent and 75 per cent respectively in 2050.

That scale of mode shift would cost $630 million in infrastructure investment, but would generate considerable net benefits overall, totaling over $13 billion by 2050 (a benefit-cost ratio of 24:1). Improved exercise levels will reduce mortality; 4000 lives saved at a value of $12.4 billion. Reductions in air pollution are worth another $78 million over that time, but this is more than offset by higher levels of cyclist injuries and fatalities with a cost of $1.45 billion.

The MfE have misreported the MacMillan study. The $630 million cost and the $13 billion net benefits relate to ambitious targets that achieve Copenhagen (40 percent) shares of cycling, not to a cycling share of five percent.

In relative terms, the health impacts of any increase in active transport are likely to outweigh the emissions reductions benefits significantly. In the Macmillan et al (2014) study mentioned above, the health benefits outweighed the climate benefits by a factor of almost 12 to 1.

Given the small emissions reduction effects, there could be a co-benefit to emissions ratio of more than one, for active transport proposals. But this does not tell us anything about the overall benefit to cost ratio, which is what should matter.

From the evidence scanned and reviewed, we have not found studies that look at the benefits of active transport on reduced congestion. In-house calculations suggest the congestion benefits could conservatively be at least four times the health benefits.

If the MfE wishes to cite its in-house calculations then it should release the detail.

Strength of evidence
The strength of evidence is strong.
Here, as elsewhere, there is a lack of clarity about the strength of evidence metric. Is it the evidence on the level of the co-benefits, which the MfE needs to support its case that co-benefits offset some of the economic costs of climate change. Or is it the evidence on the ratio of co-benefits to emission reduction benefits (which is irrelevant to answering the level of benefits question).

The Macmillan study
Taken at face value the Macmillan study looks impressive. An investment of $640 million generates benefits of about $14 billion and net benefits of over $12 billion. On inspection, however, this outcome proves to be extraordinarily flimsy.

The report discusses a number of bicycle lane investment scenarios for Auckland. The biggest investment of $640 million is the one (mis)reported by the MFE above. It assumes 'international best practice' of building separated bicycle paths on arterial routes will deliver Copenhagen levels (the highest in the developed world) of bicycle trips (40 percent compared to about one percent now) by 2051. The active transport uptake is just assumed (an exercise in wishful thinking) to flow from 'international best practice'. There is no evidence to support it, nor is any consideration given to how Auckland is different to Copenhagen

The model is complicated, with many inputs, most of which are calibrated (largely just made-up), but the critical variable driving the high benefits to cost ratio is the

number of lives 'saved' through the health benefits of cycling. We focus on this benefit, but many of the other cost and benefits in the study appeared to be biased to generate positive results. On the health benefits the model is calibrated having regard to two studies on the difference in death rates of people who cycle to work and those who don't.

The first[26] was a study on women in Shanghai aged between 40 and 70. It showed that cyclists had a lower death rate, but the effect was not quite statistically significant.

The second is a Danish study [27]of 20-93 year olds. It reports that cycling to work reduces mortality rates by 28 percent, after accounting for a number of covariates, including other exercise. In other words, even if you do other exercise, (including leisure time cycling), cycling to work will reduce your expected mortality rate by 28 percent. This looks to good to be true. If it were true we would expect Denmark to shine in international life expectancy tables. But it does not. It is ranked 27th by the WHO, below New Zealand at New Zealand at 17. We might also expect doctors to be specifically 'prescribing' cycling to work, even for patients who are getting plenty of other exercise.

There looks to be something amiss with the Andersen study, but we are not close enough to the detail to suggest what might be driving their strong result. However, there is a UK study[28], which is more relevant to New Zealand (a low rate of cycle use), which produced a similar result. There was a health benefit (a forty percent reduction in mortality) to cycling to work, but no benefit from walking. On inspection it seems clear that the work/cyclists were a different population to the rest of the population. 90 percent were getting their recommended dose of exercise, compared to only 50 percent of the walking and automobile commuters. The cyclists were not just getting their exercise from cycling to work (an average of only just 30 miles a week), but were probably generally more health conscious, in ways that were not being systematically picked up by the model. This, rather than cycling to work as such, was probably the key driver of the mortality results.

[26] Mathews et.al. 2007

[27] Andersen et. al. 2000

[28] Andersen et al. 2017 'Association between active commuting and incident cardiovascular disease, cancer, and mortality: prospective cohort study' *BMJ* 2017; 357

Other studies seem to generate less significant results. For example, a 2013 review [29]paper on the health benefits of active transport reported the following.

Twenty-four studies from 12 countries were included, of which six were studies conducted with children. Five studies evaluated active travel interventions. Nineteen were prospective cohort studies which did not evaluate the impact of a specific intervention. No studies were identified with obesity as an outcome in adults; one of five prospective cohort studies in children found an association between obesity and active travel. Small positive effects on other health outcomes were found in five intervention studies, but these were all at risk of selection bias. Modest benefits for other health outcomes were identified in five prospective studies.

Overall the results might have been positive but were not transformational.

Despite the centrality of the Danish study results to the overall cost benefit results, there is no discussion in Macmillan of its plausibility, its relevance to Auckland or of other less positive studies. Macmillan and the MfE appear to have cherry-picked the evidence.

Effectiveness of cycling promotion programmes

An obvious omission in the MfE's analysis, and in the Macmillan study, is any mention of any evidence on the effectiveness of cycling promotion investments. If people, who currently do not get enough exercise, do not respond to the improved cycling environment or cycling promotions, then there will be no health benefits. If you build it, they might not come.

There is a substantial literature here, and we discuss some relevant papers.

The first[30] is a review of 12 studies from 12 countries. Seven of the studies related to individual or group based interventions to encourage cycling. These were effective in only three of the interventions. The more relevant are the environment interventions (cycle lanes etc.), which showed only small improvements. Nowhere were there any transformational effects from these sorts of investments. The paper summarised the following studies.

The English CCT (Cycling Cities and Towns) programme aimed to increase cycling through capital and revenue investments. Changes in cycle commuting between

[29] Saunders LE[1], Green JM, Petticrew MP, Steinbach R, Roberts H 2013 'What are the health benefits of active travel? A systematic review of trials and cohort studies'.

[30] Glenn Stewart, Nana Kwame Anokye, Subhash Pokhrel 2015 What interventions increase commuter cycling? A systematic review BMJ vol 5 issue 8 2015

2001 and 2011 in the CCTs were compared with changes in matched towns. The analysis indicated that cycling to work in the intervention towns increased by 0.69 percentage points.

In Ireland, the Department of Transport set a target of increasing cycling from 2% of journeys in 2009 to 10% by 2020. There were a range of interventions, including financial incentives (tax-free loans to purchase cycles);infrastructure change (traffic calming, cycle lanes including segregated lanes), promotional events such as Bike week (family rides, removing traffic from streets, repair clinics and promotion talks), and a shared bike scheme. Census data indicated that cycle modal share fell from 6% in 1996 to 4% in 2002 and 2006, but had risen to 5% in 2011. However, it is was not clear as to what extent the post 2008 financial crisis in Ireland might have affected the results, as people might have taken up cycling out of financial necessity.

One US study assessed the effects of transport/cycle infrastructure on cycle commuting. Cycle commuter modal share increased in central Minnesota (from 2.8% to 3.3%, at the University of Minnesota and Minneapolis (from 0.788% to 0.841%), compared with the suburbs where the cycle commute share fell from 0.335% to 0.279%.

Other studies

A Danish study[31] showed that efforts to encourage cycling to school found that infrastructural changes near schools and school cycling promotions made no difference to commuter cycling rates.

A summary [32]of studies of Dutch and Danish experiences in encouraging modal changes towards cycling found increases of between 2- 9 percentage points. See their table 4 below

[31] Lars Østergaard Jan Toftegaard Støckel, and Lars Bo Andersen Effectiveness and implementation of interventions to increase commuter cycling to school: a quasi-experimental study

[32] Interventions in bicycle infrastructure, lessons from Dutch and Danish casesKees van Goeverden a*, Thomas Sick Nielsen b, Henrik Harder c, Rob van Nes
Transportation Research Procedia 10 (2015) 403 – 412

Figure seven: Modal shifts in active transport

Table 4. Modal shifts in share of all cyclists in trips in the after situation

Study	Shift from walking	Shift from car	Shift from PT	Shift from all motorized modes
Tilburg (Goudappel en Coffeng and Rijkswaterstaat, 1980)		2%	0%	
The Hague (DHV *et al*, 1980)		2%	0%	
Delft (Katteler *et al*, 1987)	3%	3%[1]	0%	3%
Bryggebroen (COWI, 2009a)		2%		11%
Åbuen		2%		
Albertslundruten		2.5%		9%
Farumruten		5%	6%	10%

1: 1% car driver, 2% car passenger

Closer to home Chapman et al.[33] compared active transport outcomes in two New Zealand cities that had active transport interventions, with two that did not. They found that

Relative to the control cities, the odds of trips being by active modes (walking or cycling) increased by 37% (95% CI 8% to 73%) in the intervention cities between baseline and postintervention. The net proportion of trips made by active modes increased by about 30%. In terms of physical activity levels, there was little evidence of an overall change.

There was no actual increase in active travel. The decline observed in preceeding years was merely arrested.

Electricity for heat

The shift to electricity for heat will have some impact on reducing emissions but will also have co-benefits for health, particularly where it results in reduced burning of wood and coal in urban areas.

This is assessment is mostly misdirected. Reducing the burning of wood is not part of the zero carbon process.

Demand management

While demand management does not provide large co-benefits based on available evidence, it does enable other co-benefits (such as public and active transport) and can prevent additional costs from emissions reductions policies.

[33] Chapman R, Howden-Chapman P, Keall M, et al. 2014 'Increasing active travel: aims, methods and baseline measures of a quasi-experimental study.' BMC Public Health;14:935.

Urban form

The way we design our cities has an impact on carbon emissions and quality of life. The quality and form of urban areas can either facilitate or hinder public transport. For example, the density and mix of immediate land uses and street network design can support the feasibility of public transport by increasing the number of people living within public transport catchments.Urban sprawl increases per capita land use by 60 to 80 per cent and motor vehicle travel by 20 to 60 per cent (Litman, 2015). This leaves less land available for other uses.

As already noted urban form is not really a climate mitigation issue, as urban form will not change materially over the relevant time horizon. Over longer horizons electric cars mean that more private commuting will not have an emissions impact.

Promoting public transport should not be a goal in itself. Most people prefer private transport. Public transport only has value when it deals with congestion problems in an economically efficient manner. Mobility for those who cannot drive may be handled more efficiently by privately provided autonomous electric cars, or vans, in the not too distant future. Real time congestion pricing would help deal with the congestion issue.

A less dense urban form uses more land, but that is because land is being put to its highest use value. The compact urban form philosophy has helped cause the economically and socially disastrous rise in city property prices in New Zealand, and has helped increase transport emissions from long distance commutes as people are driven to outlying towns where they can still buy an affordable house.

Co-benefits

Urban sprawl creates benefits as well as costs, but the benefits are generally internalised, whereas a large proportion of the costs fall on other people. International evidence suggests that sprawl increases costs per person by US$4556, of which US$1988 (44%) is external, falling on other people (Litman, 2015). Therefore, dense urban planning can produce some cobenefits as well.

Litman ignores consumer surplus from consumer 'sprawl', overstates the external costs, and ignores external costs(e.g. noise) generated by denser environments.

An emphasis on 'proximity planning' can reduce emissions by making public and active transport more feasible for people, at a cost as low as $2 per tonne of CO2-e saved (WHO, 2012).

The full summary in the WHO report is as follows:

More compact land use that integrates urban residential and commercial areas enhances the climate and health co-benefits of transport strategies. Emphasis on "proximity planning"

makes walking, cycling and public transport to jobs, schools and services more feasible. For example, one study of Santiago, Chile projected that relocating schools closer to homes could reduce GHGs by 12% over a 20-year period at a cost of only US$ 2 per tonne of CO2 reduced.

Schools in New Zealand are already closely located as possible to the communities they serve. Where they are not, moving them would be very expensive.

Around one-tenth of the best horticulture land in New Zealand has been lost to housing in the past decade, contributing to the increased cost of fruit and vegetables (Hutching, 2016). The cost of this issue has not been quantified, so there are no estimates of the size of co-benefits for the food system.

There was no evidence in the Hutchings article on the impact on fruit and vegetable prices. It is unlikely that putting land to its highest value use in urban housing and shifting horticultural elsewhere will affect New Zealand fruit and vegetable prices. It might just slightly reduce exports.

Carbon capture and storage

The co-benefits for Carbon capture and storage (CCS) are similar to those of shifting to alternative fuels, at best potentially allowing for a small reduction in air pollution.

Industrial Processes and Product Use (IPPU)

No co-benefits have been identified from reducing IPPU emissions.

Agriculture

Improved farm practices

Improved farm practices make more efficient use of resources, which in the context of emissions reduction usually translates into reducing inputs without reducing production (or at least without reducing profitability).

This is hard to argue with.

Livestock numbers

The final emissions mitigation available to farmers is reducing livestock numbers. In conjunction with improved farm management practices, it may be possible to reduce livestock numbers slightly without impacting on production or profitability. However, beyond this point, reduced livestock numbers would come at some cost.

True.

If there was reduced consumption of red meat, however, we might expect to see some health benefits. For example, a 30 per cent drop in the consumption of saturated fat in the United Kingdom is expected to reduce heart disease by 15 per cent (Watts, 2010).

The reduction in red meat consumption in New Zealand would result in more exports. The level of emissions would not fall. This is a (controversial) health argument rather than a New Zealand emissions argument.

There may also be some benefits of diversifying land use away from dairying and meat production, which are currently two of New Zealand's top exports. With synthetic factory meat and milk threatening to dominate the commodity market in coming years, diversification of land use could reduce the potential of a price shock hitting the New Zealand economy, similar to when nylon began to displace wool in the 1960s. The scale of such potential co-benefits is speculative and difficult to estimate.

The diversification argument may not be a bad idea, but any response is best left to the market.

In New Zealand, red meat consumption above the recommended level (leading to heart disease, stroke and colon cancer) has resulted in an estimated 4078 premature deaths each year (Springmann et al, 2016).

We found no reference to New Zealand premature deaths in the study, which reported the results of a regional global health model.

Waste sector emissions

From the evidence scanned for this report, no specific co-benefits have been identified from reducing waste emissions, other than the direct financial benefits of reducing waste to landfill, freeing up resources for reuse and the ability to use land for other uses.

There may, however, be a net financial cost in reducing waste to landfills if uneconomic investments are pursued. An emissions reduction focus, at all costs, makes these outcomes more likely.

We note, however, the study by Blick and Comendant (2018) who investigated the emissions reduction opportunities of transitioning to a circular economy in Auckland. They estimate the emissions reductions in the waste sector from a circular economy could total 1395 kilo-tonnes of CO2-e in 2030.

The emissions saving in the Blick and Comendant report was based on three major savings (the rest were trivial).

- A 50 percent saving in food waste. Goof luck with that. Even if this were possible it would not reduce New Zealand's agricultural emissions much because lower domestic demand would result in higher exports.
- Emission reductions from electric cars relied on some optimistic uptake assumptions.

- Car sharing might reduce the capital cost of the vehicle fleet but, in itself, it does not reduce transport emissions. A journey is a journey whether the car is owned or rented.

Land Use, Land-Use Change and Forestry (LULUCF)

Land-use change to forestry can have real benefits for biodiversity and water quality, as well as soaking up carbon.

The value of co-benefits will depend on the exact type and location of the trees planted, and are difficult to generalise at a national level. However, Yao & Velarde (2014) give an idea of the relative values for one catchment (Ohiwa). They estimated the ecosystem value of each hectare of plantation forestry was $5600 per year.

There are co-benefits from forestry, but the benefits in the Ohiwa study are grossly overstated.

We reviewed the analysis in the report 'Ecosystem Services in the Ōhiwa Catchment'. The estimate of the econsystem value of improved water quality is, put bluntly, nonsense. This requires some explanation. The purpose of the report was to calculate the ecosystem values (including marketable outputs and postive and negative environmental impacts) for all land based activity in the catchment.

The most important positive for forests was the value of reduced nitrogen leaching. Here they set up an notional 'cap-and-trade scheme'. It is assumed that forests leach 3 kg. per hectare, but the forest owner is allocated a cap of 10 kgs. So they have 7 kg. to sell at a price of $400/kg. This generates an income of $2800, which is 'water quality' benefit.

The source of the $400 estimate was a short power point conference presentation. [34] Under the heading 'Likely incentives below the line' there was a bullet point. $400/kg? It is not clear what point the presenter was making here, but it certainly did not provide robust evidence for the $400/kg estimate that drove the Ohiwa catchment results.

The serious error here is that the $400/kg is not remotely near to the nitrogen leaching price that would emerge in a real market. At $400/kg a dairy farmer with an operating income of less than $1700 a hectare would pay a leaching charge of $12,000 a hectare. Sheep and beef farmers will pay $3200 on an income of $156.

[34] Barns, S. (2014). Lake Rotorua: Incentivising land use change In *NZARES Conference*

The only rational response would be immediately converted to forestry to collect the $2800 leaching income. Of course there would be no one left to buy the emission units, and the price would collapse to zero, or close to it.

The other key driver is the assumption that foresters would be generously allocated a cap of 10kg, of which 7 kgs, amounts to a gift. This is a transfer, not a representation of the economic value of the emission right.

Again this points, at least, to carelessness by the Ministry. If they are to cite a study then they should read it and ensure that the results are robust.

There are co-benefits from increased afforestation, but they are, on average, nowhere near the $5600 reported in the Ohiwa study.

MfE's conclusion

In the conclusion there is a discussion on the significance of the co-benefits.

It is difficult to compare the size of co-benefits for different policies, given they have been estimated with vastly different methodologies.

The best method we have of comparing is the relative size of co-benefits compared with emissions reductions benefits. The areas with relatively large co-benefits are more likely to have significantly different benefit cost ratios for investment if the co-benefits are included.

It is not difficult to compare (and aggregate) the size the co-benefits if they are quantitied in dollar terms. The problem is that the MfE has not seriously attempted to do so, to support its argument that these benefits are large. If precise estimates are lacking, then rough estimate should have been attempted. If even rough estimate are lacking then, obviously there no basis for calculating the the ratio of co-benefits to emission reduction benefits.

Based on this ratio approach (see their table 1 below), energy efficency, freight to rail, public transport and active transport are identified as the most likely candidates where co-benefits are likely to be important. There is no actual calculation of the ratios. Forestry is counted as having a high co-benefit to emissions benefit ratio. This is assesment appears to be based on the flawed Ohiwa estimate, but is obviously wrong. Forestry has very strong emissions benefits, which will, on average be bigger than the co-benefits.

Figure eight: MFE summary of co-benefits

Table 1: Summary of co-benefits relative to emissions reductions

	Size of co-benefits relative to emissions reductions		
Sector	**Low**	**Medium**	**High**
Energy	Alternative fuels Electric vehicles Renewable electricity Demand management CCS	Electricity for heat **H**	Energy efficiency **H** Freight to rail **C H** Public transport **C H** Active transport **H C**
IPPU			
Agriculture	New technology (methane)	Farm practices **W** Livestock numbers **W**	
LULUCF			Forestry **W B**
Waste	Reduce Reuse		

Co-benefits key: Health = **H**; Congestion = **C**; Biodiversity = **B**; Water quality = **W**

This 'ratio of co-benefits to emissions benefits' argument simply doesn't make sense. Consider two climate change investment proposals with the following characteristics.

Table four: Economic and co-benfit ratio investment assessments

Proposal	Net financial benefit $'m	Emission benefits $m	Other external benefits $m	Ratio of co-benefits to emission benefits $m	Net economic benefits $m
A	--3000	6	300	50	-2650
B	-100	125	25	0.2	+50

Under the MfE approach Investment A (roughly modelled on the Auckland rail link project[35]) with a ratio of co-benefits to emissions benefits of 50, looks to be a much better bet than investment B with a ratio of 0.2. The 'logic' behind this approach is that the less effective the emission mitigation, the higher the ratio and the more attractive the proposal.

Possibly, the real motivation behind this 'methodology' is that it puts some recent and prospective government policy initiatives in a good light. Energy efficiency was

[35] The $6 million emission benefit for the Auckland rail link was overstated. It did not count the emissions cost of the construction works (cement etc). The net effect is probably an increase in emissions.

part of the 'healthy homes' policy; the government has recently announced a big investment in rail. No doubt more public and active transport initiatives will follow.

Co-costs

The economic analysis assumes that emissions are abated at least cost. However, in this 'holistic' world where all sorts of unpriced 'benefits' are bundled together, analytical rigour tends to fade and there is an enhanced risk of 'co-costs'. A co-cost occurs when an emission reduction effect is used to partially justify direct interventions and projects whose costs exceed the benefits. The emission reduction effect should be picked up in a cost benefit analysis through a carbon shadow price, or will be already captured by the emission trading regime when it is fully operative. However, what is likely to happen in many cases, is that there won't be a robust assessment and that the emissions reduction impact, however small, will be used to justify somebodies pet project.

Part seven: Innovation benefits?

The MfE's case for strong and early action also places a heavy weight on innovation. It wil, we are told, reduce the cost of emission reductions and providing wider benefits for the economy. New Zealand business will get a 'first mover' advantage over the rest of the world. The MfE's arguments are based on two papers. The first, by Sense Partners, examined the implications of climate targets for competiveness leakage and innovation. The second was the MfE's own review of the overseas literature.

In this part we review both papers in depth.

Sense Partners: 'Countervailing Forces: Climate Targets and Implications for Competitiveness, Leakage and Innovation'

International evidence

The report starts with a review of the international literature, which generally paints a poitive picture of the impact of environmental policies on innovation.

Overseas evidence provides qualified support for significant adjustment and potential for positive impacts through increased innovation and even productivity improvements

The OECD (Albrizio et al, 2011) has analysed environmental policy stringency across countries and found that it is generally associated with increased productivity. Indeed, this finding is a variant on a growing body of empirical research which refutes presumptions that environmental policy causes productivity losses and production to relocate.

As we shall see in our assessment of MFE's review of the overseas literature, which covers the same ground, but in more depth, this optimism is somewhat overstated. Also, the Sense report did not consider agricultural innovation, noting that no other country has, or is considering, including agricultural emissions in their emissions pricing schemes. (with the exception of Kazakstan, where the ETS inclusion is described as being 'on ice').

New Zealand emperical evidence

The key contribution of the paper is some New Zealand emperical analysis that points to a less favourable conclusion on the reponse of innovation to higher energy prices.

To quantify the impacts of energy price increases Sense used a simple model of the empirical relationship between sectoral energy prices and sectoral outputs. They then estimated the impact of an increase in energy prices on value added over 1, 2 and 15 years after an initial shock. Aside from the mining sector, an increase in energy prices decreased value added in every sector. The impact of the energy prices was persistent.

even 15 years after the shock there is little evidence of a rebound in output consistent with innovation in response to the shock and *In several cases, the reductions in value added are roughly proportional to the change in energy costs..*

The evidence leads to the following assessment

New Zealand firms have, for some time, been poor performers in productivity growth and innovation, as discussed in the next section, which begs the question as to why climate policy would change this.

It is also notable that sectors which have high leakage risk have, typically, not experienced strong productivity growth in the past. Indeed, most of these industries – in particular steel, cement and aluminium – are not industries in which New Zealand has any comparative advantage or pre-existing distinctive stock of knowledge.

New Zealand's productivity and innovation malaise is also likely to limit innovation aimed at reducing emissions. For example, although research indicates that environmental policy

stringency drives productivity growth, at least for a time, this is not the case for economies that are behind the pace relative to global best practice (Albrizio et al, 2017).

More generally there is a concern from some economists that innovation targeted at reducing emissions will reduce the amount of resource available to other innovation efforts.

What data there is, such as on productivity growth, casts some doubt over whether innovation and adaptation by New Zealand firms will be sufficient to overcome potentially wide cost differentials. ***To presume that climate policy could make the difference would be a kind of exceptionalism and a serious leap of faith*** (our emphasis)***.***

These are strong words coming from a consultant. They are generally reluctant to bite the hand that feeds them.

The takeout here is clear. There is no support in this report for the MfE's 'innovation bonus' claims for New Zealand. The MfE simply ignored the advice.

MfE 'Emissions pricing impact on innovation and competitiveness A review of the international literature'

This MfE report reviewed just the international literature on the impacts of emissions pricing on innovation and competitiveness. It concluded that

- Emissions pricing at current levels reduces emissions, but does not weaken the overall economic performance of most businesses.
- While some emissions-intensive and trade-exposed sectors show potential for emissions leakage and negative economic impacts with emissions pricing, these negative impacts are small.

It is not clear why the MfE review was conducted. Sense Partners had already reviewed the international literature and came to a similarly generally upbeat conclusion, only to find that they didn't apply to New Zealand. At the end of its lengthy review the MfE implicitly concedes, albeit reluctantly, that the overseas evidence may be of limited relevance to New Zealand.

- *Compared to the EU, some New Zealand sectors would be more trade-exposed.*
- *while the international evidence suggests emissions pricing can reduce emissions, while not weakening overall economic performance of most businesses, this is at current international prices. It remains speculative) as to whether these trends will hold at much higher emissions prices (eg, over $200/tCO2-e) that may be needed for a transition to a low-emissions economy in New Zealand regulation.*

However, this caution does not find its way to the postive innovation story that prevades the MFE and other narratives. It appears the real purpose of the review was to provide a cloak of support for the innovation story. But when we work our way through the evidence we find the cloak is somewhat threadbare and that the Ministry has overstated the positive side of the evidence, and mostly ignored anything negative.

The 'pollution haven' and 'Porter' hyprotheses

The MfE discussion is set up as a contest between two economic theories – the 'pollution haven' hypothesis and the 'Porter' hypothesis.

The 'pollution haven' hypothesis states higher emission prices under stronger climate action increases compliance costs, diverts scarce resources away from productive activities, and therefore reduces competitiveness of regulated businesses. These impacts may shift emissions-intensive production off shore toward countries with low abatement costs eventually and cause policy-induced emissions leakage.

In contrast, the 'Porter' hypothesis argues stronger climate action, especially higher emissions pricing that draws on the power of markets, can have a net positive economic impact on the competitiveness of regulated businesses. Such policies promote cost-cutting resource efficiency improvements and foster policy-induced innovation in new low-emissions technologies that may help businesses grasp first-mover advantages.

Ex-post analyses

There is a review of ex-post analyses, (primarily of the European Union emission trading scheme), which concludes that carbon pricing did impact on emissions and encouraged innovation. The key paper cited is Dechezlepretre (2018) which was the first comprehensive, European-wide analysis of the EU ETS. We discuss what this paper actually found below.

Qualitaive surveys

There is also a discussion of qualitative surveys.

For example, Loschel et al (2010) surveyed 120 German businesses, and only six per cent indicated that the explicit objective of emissions abatement was the key factor for reducing emissions. *This survey indicated that emissions reductions were driven largely by factors that led to resource efficiency improvements, including switching to less emissions-intensive production processes (eg, switching from coal to gas).*

All this was showing is that the fall in natural gas prices had a major impact on energy use.

Another similar survey found 94 per cent of Swedish businesses regulated under the EU ETS indicated they would not reduce their production volume to abate emissions, instead they placed greater emphasis on improvements in resource efficiency (Sandoff & Schadd, 2009).

This is not really a surprise, the emissions prices very low and would not be expected to have a material impact on output.

And it is concluded

If resource efficiency improvements occur as a result of emissions pricing, it is reasonable to conclude that the improvements are likely to be the result of policy-induced innovation.

However, we cannot draw many conclusions from these studies. They are just surveys, and some respondents may have been concerned to say the 'right thing'. Also we cannot just assume that all of the firms' actions were economically efficient Some may have been just virtue signalling. In other cases, the increased focus on energy efficiency may have led firms to identify the the low hanging fruit and make economically efficient changes. This may not tell us much about the responses of trade exposed industries, when the going gets tougher, and when the easy gains have already been have made.

Impact on competitiveness

Until more recently, research has generally concluded that emissions pricing has no significant impact on competitiveness. Arlinghaus (2015, p. 23), in reviewing a wide set of papers concluded that "most studies reviewed […] fail to measure any economically meaningful competitiveness effects as a consequence of these [emissions pricing] policies."

More recent studies appear to suggest even stronger findings than no significant impact on the economy from emissions pricing. ***These papers, indeed, provide evidence that counters conventional wisdom and indicates some support for the Porter hypothesis***,(our emphasis*) where innovation not only softens competitiveness impacts, but may provide net positive economic impacts.*

Again, the problem with these studies is that they are analysising low emmission prices, and do not distinguish trade exposed industries. Most of the exposed industries had free allocations, and small firms were not exposed.

The latest, most comprehensive and useful, study is the 2018 OECD Dechezlepretre study noted above. Here the MFE is unbeat about the results

Evidence potentially supporting the Porter hypothesis is also observed … from his analysis, Dechezlepretre (2018) concludes that the EU ETS not only had no negative impact on economic performance of regulated businesses, but also led to a statistically significant

increase in revenues of between 7 to 18 per cent, and fixed assets by 6 to 10 per cent (see table 1).

Further analysis needs to be undertaken to understand the mechanisms behind the results, but free allowances and the pass-through of costs are likely to explain only a small percentage of these positive findings.

A close look at the Dechezlepretre results does not support the MFE's conclusions.

On emissions reductions Dechelzepretre found:

- Emission reductions were only statistically significant in the second phase (from 2012).
- There was an emissions reduction effect only for the largest firms (fourth quartile).
- Smaller firms actually **increased** their emissions relative to their control group.
- By sector there was a statistically significant effect only for the chemical industry

The large and smaller firm effects are relevant to New Zealand, with our preponderance of small firms.

Comparitive economic performance was measured by the impact on firm revenue and profits.

- EU ETS firms increased employment and profits compared to the non-ETS control firms, but this difference was not statistically significant.
- Returns on assets (i.e. profits scaled by assets) did not experience any statistically significant change compared to the control group.
- Smaller firms saw no statistically significant change in their profits and a statistically significant **decrease** in their return on assets, a finding which is compatible with larger firms being more able to pass-through the costs of carbon emissions onto their customers. Small firms had to wear a fall in their return on their investment.
- A postive effect on the electricity sector droves some of the results. This sector got a big public subsidy from the allocation of free emission units, while prices were driven by the marginal costs effect of the emission price.
- Companies operating in sectors at risk of carbon leakage experienced difficulties compared to firms not judged at risk. After 2005, their assets decreased by around 17%, employment went down by around 13% and profits also decreased in absolute terms (but not when divided by assets, which decreased even more).

The most reasonable interpretation of Dechelzepretre is that it provides evidence that refutes, rather than supports the Porter hypotheses.

Getting back to the MfE review.

Finally, Yamazaki (2017) also finds positive economic impacts where the revenue-neutral BC carbon tax generated a statistically significant two per cent increase in aggregate employment in the Canadian province. This suggests double dividends are achievable in the sense that the carbon tax can reduce emissions, the first dividend, and the revenues can be used to reduce the effects of more distorting effects in the tax system, the second dividend.

The study also found that employment in the trade exposed chemicals industry fell by 37 percent, and that the biggest increase was in the health care services sector (an increase of 18 percent). It was unlikely that any of the health sector increase was driven by a carbon tax of $C 10/ t. More likely it was driven by exogenous policy changes that were not captured by the model. The study also also found that wages fell by 1.6 percent.

It seems that the Canadian study results, which should be taken with a grain of salt at least to the size of some of the effects, refutes the Porter hypotheses. The trade expose sector was adversely affected.

Kahn and Mansur (2013) also examined variations in energy prices and climate policies among adjacent United States counties between 1998 and 2009. They found evidence that energy intensive sectors tend to locate in low electricity price areas, and that emission-intensive sectors seek out low-policy stringency areas; thus reducing employment in high-policy stringency areas.

Fowlie et al (2016) found emissions pricing has two negative effects in the Portland, United States cement industry. In particular, the authors found emissions pricing exacerbates 'market power' distortions, and emissions leakage offsets domestic emission reductions.

So more evidence against the Porter hypothesis.

On the other hand, Aldy and Pizer (2015) found statistical evidence that while higher energy prices led to small reductions in output in United States manufacturing businesses, they did not observe an increase in net imports. This highlighted that the production decline may be result of a decline in domestic consumption only. This result suggests consumers of energy-intensive manufactured products do not consume more imported products in response to higher energy prices, but instead economise their consumption of higher priced manufactured products.

This looks to be an odd result, which is worth a closer look. The abstract of the Aldy and Pizer paper reads.

In order to evaluate this hypothesis, we undertake a two-step empirical analysis. First, we use historic(sic) *energy prices as a proxy for climate change mitigation policy. We estimate how production and net imports change in response to energy prices using a 35-year panel of approximately 450 U.S. manufacturing industries.*

Second, we take these estimated relationships and use them to simulate the impacts of changes in energy prices resulting from a domestic climate change mitigation policy that effectively imposes a $15 per ton carbon price.

We find that the higher energy prices associated with this carbon price would lead to a production decline of as much as 5 percent among key energy-intensive sectors (e.g., iron andsteel, aluminum, cement, etc.). We also find, however, that this energy price increase would translate into a smaller-than-one-percent increase in net imports, reflecting either a lack of substitutability with foreign goods or a lack of additional global capacity over the horizon we examine (one to three years via various lagged models). The approximately eight-tenths of a percent shift in energy-intensive production overseas is our estimated adverse competitiveness effect.

The weakness in this study is that the historicial estimation model did not assess the effect of differences in energy prices between countries. Energy prices price changes will tend to be correlated world wide and correlated price increases would not, in themselves, be expected to impact on import intensity. So they don't find much of a trade effect. The explanation that imports of commodities such are iron and steel aluminium and cement are not substitures for domestic production or that there is a lack of global capacity are obviousy wrong.

This is another case of the MfE seizing on an apparently positive study, without applying any quality control test.

The agricultural sector

The only study examined in the review was Rivers and Schaufele (2014), who investigated the impact of the British Columbian carbon tax on the competitiveness of the agricultural sector. They found no statistically significant relationship between agricultural trade and the tax. They also found that agricultural commodities and products were neither trade-intensive nor fossil fuel intensive. And of course cnanaian agriculture is heavily protected, so competitiveness issues could not arise for some products. These results are obviously not relevant to New Zealand.

Ex-ante analyses

The ex-ante analyses use models to forecast the impact of projected emission price impacts on variables of interest. The MFE first attempts to downgrade the

significance of these studies on the grounds that they only take limited account of the innovation stimulus effect.

Most ex-ante analyses of the impacts of emissions pricing have been done by computable general equilibrium (CGE) modelling frameworks. Within these frameworks, limited effort has been undertaken to adequately account for the stimulation of innovation promised with emissions pricing. Hence, the emphasis of the literature applying ex-ante analysis via CGE modelling has been on the issues of competitiveness and emissions leakage. The analysis is implicitly grounded in conventional wisdom that broadly follows the pollution haven hypothesis.

We have only the MFE's assessment that the models take 'inadequate' account of the innovation stimulus effect. Given the limited evidence to support the MFE's preferred model, it is not suprising that modellers have not built too much wishful thinking and speculation into their models.

The MfE then report the results of the Carbone and Rivers (2017) review of the ex-ante analysis literature on emissions pricing impacts. They found output in EITE (emissions intensve trade exposed) sectors decreases as the regulating country abatement rate increases. A 20 per cent reduction in a regulating country's emission levels generated a reduction of around five per cent and a seven percent reduction in exports.

The Porter hypotheses goes missing

Having set the stage in terms of a 'contest' between between the 'Porter' and 'emission haven' hypotheses, the MFE neglects to make an assessment of the strength of the evidence supporting one side or the other. However, there is a review in Dechezleprêtre and Sato 'Green policies and firms'competitiveness (2017)',which was referenced, but not discussed by the MfE.

This is what it has to say on the Porter hypothesis.

While there is evidence that the actual cost of achieving an environmental objective is usually smaller than anticipated because of induced innovation (see e.g., Harrington et al., 2000 and 2010; Simpson, 2014), the literature to date does not provide much empirical support for the Porter hypothesis

Thus, there is currently no empirical evidence that environmental regulation leads to an increase in firm competitiveness through its effect on innovation.

There is some emerging evidence, however, that regulation-induced environmental innovations tend to replace other innovations, leaving the overall level of innovation unchanged.

Several studies have examined the causality chain implied by the Porter hypothesis -- from regulation to innovation to profitability-- and find that the positive effect of innovation on business performance does not outweigh the negative effect of the regulation itself (Lanoie et al., 2011).

The MfE's Conclusions

This report has reviewed the international literature on the impacts of emissions pricing on innovation and competitiveness. It has investigated extensively the literature regarding ex-post analysis and also considered ex-ante analysis. Given the ex-post analysis is less manipulated by underlying assumptions, conclusions formed are based primarily on this evidence.

So the ex ante evidence, which is not favourable, is ignored.

Based on the review of the international literature, the report concludes that emissions pricing at current levels reduces emissions, while not weakening overall economic performance of most businesses.

Recent preliminary evidence suggests stronger conclusions, where emissions pricing may also provide small positive economic impacts (eg, Klemetson et al 2016; Yamazaki, 2017; Dechezlepretre, 2018)

These conclusions as to the overall economic impact from emissions pricing need to be moderated. Findings also reveal some EITE sectors show potential for emissions leakage and negative economic impacts with emissions pricing, although these negative impacts are also small.

As discussed above this is a misrepresentation of the Dechezleprtere study, and overstates the signifciance of the Yamazachi analysis. Klemetson et al was not mentioned in the MfE's discussion, so it is not clear why it appears in this conclusion. This Norwegian study indicates that there was little impact on emissions, and that firms probably benefited at the expense of consumers.

The results indicate a weak tendency of emissions reductions among Norwegian plants in the second phase of the ETS, but not in the other phases. We find no significant effects on emissions intensity in any of the phases, but positive effects on value added and productivity in the second phase. Positive effects on value added and productivity may be due to the large amounts of free allowances, and that plants may have passed on the additional marginal costs to consumers.

Our conclusion

The MfE's innovation optimism story is not supported by the literature and the MfE has often misunderstood, or has misrepresented the evidence.

Part eight: Defence and climate change

In this part we look at a case example of how climate change 'hysteria' has corroded the capacity for critical and rational thought in government circles. In December 2018 the Ministry of Defence (Defence) issued a *paper 'The Climate Crisis: Defence readiness and responsibilities'. T*he document was signed by Helene Quilter, Secretary of Defence and K.R. Short, Air Marshal Chief of Defence Force

Defence tells us

This Defence Assessment draws on extensive research and eight months of New Zealand and South Pacific-based discussions on climate change and security with officials from countries across the Pacific, notably member countries of the South Pacific Defence Ministers' Meeting, as well as with academics and civil society from across New Zealand and the Pacific region.

However this 'extensive' research is supporte by just four references. The first [36].' *Autumn cooling of western East Antarctica linked to the tropical Pacific'.* is a scientific study with no obvious connection with defence and security issues

The second is a figure from *'Preparing for Coastal Change. A Summary of Coastal Hazards and Climate Change Guidance for Local Government (Ministry for the Environment, December 2017),* which shows New Zealand's economic zone and search reponsibility areas.

The third[37], *'Perfect storm' of climate change and growing conflict',* is nothing more than a story about a recent visit to New Zealand by the head of the Red Cross. He is reported as saying *'There is a perfect storm building up between the deveoment of climate change … which in certain respects we see unfolding in parts of Africa, parts of the Middle East and even in the Pacific'.*

It seems that just the mention of the Pacific was sufficient to elevate this brief news item to the top of Defences's security and climate change evidence base.
The fouth[38], '*Freshening by glacial meltwater enhances melting of ice shelves and reduces formation of Antarctic Bottom Wate'* is about the effects of ice shelf melting, again with no obvious linkage to security issues.

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[36] Clem, K. R., Renwick, J. A., & McGregor, J. (2018).' Autumn cooling of western East Antarctica linked to the tropical Pacific'. Journal of Geographical Research: Atmospheres, 123, 89-107

[37] Sachdeva, S. 'Perfect storm' of climate change and growing conflict. (newsroom, 4 October 2018),

[38] *Silvano et al.*, '*Freshening by glacial meltwater enhances melting of ice shelves and reduces formation of Antarctic Bottom Wate'Sci. Adv. 2018; 4,*

The climate science

There is no serious analysis of predicted climate changes in the Pacific over coming decades, of the economic implications, or how the changes feed through to security concerns. The 'analysis' mainly takes its direction from on a statement from the 2018 Pacific Islands' Forum.

At the 2018 Pacific Islands Forum, leaders affirmed that "climate change presents the single greatest threat to the livelihood, security and wellbeing of Pacific people". The current effects of climate change in the region, let alone the future intensity increase, demonstrate the salience of this declaration.

Fortunately we do have a good scientific assessment of future climate changes for Pacific island countries in the report *'Climate Change in the Pacific: Scientific Assessment and New Research* Climate Change in the Pacific' (2011) produced as part of the International Climate Change Adaptation Initiative and funded from the Australian Aid Pacific climate change science program.

It describes itself as

' a rigorously researched, peer-reviewed scientific assessment of the climate of the western Pacific region. Building on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, this two volume publication represents a comprehensive resource on the climate of the Pacific.'

It is supplemented by updated country studies in the 2014 report *'Climate Variability, Extrennes and chnages in the Western Tropical Pacific: new Science and Updated Country Reports'*

A summary of the extrene events analysis of the countries most relevant to New Zealand, presented in the latter report, is set out in table three.

Table five: Pacific islands' Extreme climate event projections

	Extreme rain	***Drought***	***Cyclones***	***Sea level rise***	***Wind driven waves***
Cook islands	For the Southern Cook Islands, the current 1-in-20-year daily rainfall	For the Southern Cook Islands the overall proportion of time spent in	In the Cook Islands, the projection is for a decrease in	7-17 cm 2030	No change

	amount is projected to increase by approximately 7 mm by 2030 for RCP2.6 and by 9 mm by 2030 for RCP8.5.	drought is expected to decrease slightly under RCP8.5 and stay the same under all other scenarios	cyclone generation The confidence levelfor this projection is high.		
Fiji	The current 1-in-20-year daily rainfall amount is projected to increase by approximately 5 mm by 2030 for RCP2.6 and by 7 mm by 2030 for RCP8.5 (very high emissions).	Time in drought decresses slightly iin all scenarios	the projection is for a decreasein cyclone genesis (formation) frequency	A rise of between 8–18 cm by 2030 (very similar values for different RCPs), with Increases of 41–88 cm by 2090 under RCP8.5	A decrease in mean wave height of 8 cm in 2090
Kirbati	For the Gilbert Islands the current 1-in-20-year daily rainfall amount is projected to increase by approximately 6 mm by 2030 for RCP2.6 and by 8 mm by 2030 for RCP8.5	For the Gilbert Islands the overallproportion of time spent in droughtis expected to decrease underall scenarios.		7-17 cm by 2030	Projected decrease in November–April wave height (significant in February and March in 2035 under RCP8.5
Papua New Guinea	By 2030, the current 1-in-20-year daily rainfall amount is projected to increase by approximately 14 mm under RCP2.6 and 12 mm under RCP8.5. By 2090, it is projected to increase by approximately 21 mm for RCP2.6 and by 55 mm for RCP8.5.	The overall proportion of time spent in drought is expected to decrease in most locations under all scenarios	A decrease in cyclone genesis (formation) frequency for the south-west basin	7-17 cm by 2030	
Samoa	The current 1-in-20-year daily rainfall amount is projected to increase by approximately 10 mm by 2030 for RCP2.6 and by 8 mm by 2030 for RCP8.5.	The overall proportion of time spent in drought is expected to decrease slightly under RCP2.6 very low emissions) and remain	Projection is for a decrease in cyclone genesis (formation) frequency for the southeast basin In Samoa, the confidence level for this projection is high	7-17 cm by 2030	No change

		approximately the same under all other scenarios.			
Solomons	The current 1-in-20-year daily rainfall amount is projected to increase by approximately 9 mm by 2030 for RCP2.6 and by 9 mm by 2030 for RCP8.5.	For the Solomon Islands the overall proportion of time spent in drought is expected to decrease under all scenarios.	The projection is for a decrease in cyclone genesis (formation) frequency for the south-west basin	7-17 m	A decrease in mean wave height (significant under The very high emission RCP8.5scenario in 2090) accompanied by a decrease in wave period,
Tonga	The current 1-in-20-year daily rainfall amount is projected to increase by approximately 7 mm by 2030 for RCP2.6 and by 4 mm by 2030 for RCP8.5.	For Tonga the overall proportion of time spent in drought is expected to decrease slightly under all scenarios.	In Tonga, the projection is for a decrease in cyclone genesis (formation) frequency for the south-east basin The confidence level for this projection is high.	7-17 cm.	A slight decrease in wave height

The evidence is fairly clear. Cyclones, which might require a post-disaster response from New Zealand defence forces are projected to become less, not more, frequent (though the ones that do occur might be a little more intense). Droughts becomes less frequent; extreme rainfall events (mostly an opportuniy to fill water tanks rather than a dire threat to infrastructure), get only a little more 'extreme', and waves will generally be a little less threatening.

The sea level will increases a little over the next couple of decades andwill eventually pose a threat to the low lying atoll countries of Kiribati, Tuvalu and the Marshall islands (with a combined population of 200,000). This may have implications for New Zealand and Australia's future immigration and aid policies, but this has little to do with Defence's current challenges.

But this is not how Defence sees the climate science. In its 2019 Defence Capability plan it says:

The dramatic climate effects the Pacific region is facing, stemming from rising temperatures, include continued sea level rise, increased frequency and intensity of extreme weather events such as storm surges, increased intensity of tropical cyclones, and more variable rainfall patterns and prolonged droughts. The implications of these effects include a range of

environmental impacts, all of which have flow-on economic, cultural and social consequences.

And the implications are

With current warming rates, the links between climate change and security are on course to intensify, and without prioritisation the New Zealand Defence Force, as well as those of our partners, will be stretched with a growing number of tasks in response to climate-induced impacts globally.

Higher levels of readiness will be required to ensure New Zealand is able to respond to events of decreasing predictability. Greater capacity will also be required

The Australian funded reports are obviously the 'go-to' starting point documents for any assessment of the security implications of climate change in the Pacific. Either the Ministry failed to find them in an eight month research effort (it took us less than eight minites), or they deliberately suppressed the evidence, because it did not support their preferred narrative.

We are also told that climate change impacts on New Zealand will have implications for the Defence forces. But there is no discussion of the predicted changes set out in the MfE's 2018 document, which as discussed above, do not raise seriously elevated 'disaster related' concerns, even looking ahead many decades There is no evidence that the Defence is even aware that the document exists.

The intersection between climate change and security

The 'Climate crisis' report makes a concerted attempt to drawn a linkage between climate change and security risks. It is claimed

the linkage between climate change and security are indirect but demonstrable.

The problem is that Defence demonstates almost nothing in its discussion, beyond some general statements they have probably cut-and-pasted from elsewhere, and some unsupported assertions about events in the Pacific. At most it is an argument that somewhere in the world, sometime in the future, climate change might have security implications for somebody. This is no doubt true, but this is a long way from supporting Defences' argument that climate change is a major existential challenge for the New Zealand defence force. Its full assessment is repeated below. We thought it best to leave Defence to speak for themselves.

When the effects of climate change intersect with a complex array of environmental and social issues, they can be a significant contributor to both low-level and more violent conflict.

The security implications of climate change are further magnified in areas dealing with weak governance or corruption. The ways climate change is affecting the Pacific region, and the pace and magnitude of the impacts, have drawn leaders in the region to consider climate change as a threat in its own right.

Globally, climate change is most acutely affecting states less equipped to respond at pace, including in the Pacific region. Pacific communities hold important local and indigenous knowledge that can enable climate change mitigation and adaptation, which works to increase local resilience. The persistent nature of climate change and the flow on social, economic and health implications of increasingly intense environmental changes are, however, challenging communities across the region. Reducing arable land and depleting fresh water supplies are adversely affecting community health.The impacts can cause added stress to communities in post-conflict environments, including in the Autonomous Region of Bougainville and the Solomon Islands.

Many Pacific peoples have expressed their desire to remain on their land as long as possible, but some communities have already had to relocate and more climate-induced migration is inevitable. Climate migration has already caused some community-level conflict within the Pacific. Across the region, there have been instances of communities being split up for relocation, some being moved to areas with different cultures without prior consultation with the host communities, and others being moved into already crowded areas. In such cases, there have been reports of low-level conflict over land— sometimes deadly—and reports of increased levels of violence, including against women and children. When not well managed, climate migration has the potential to heighten security concerns, in the Pacific and extending into both maritime Southeast Asia and South Asia.

Against this background, there is a clear requirement to advance national and international discussions across the region on the links between climate change and security. Climate change and conflict are more readily explored in discussions and academic research in relation to the Middle East and Africa than the Pacific. Globally, disagreements in relation to climate change—such as in relation to the Paris Agreement—could influence broader relationships between states as well as affect collective responses. Some states could look to use assistance in climate change disaster adaptation, mitigation, response, and recovery as a way to increase influence and access. Working with Pacific Island countries on climate change, including in the security sphere, is an opportunity to learn lessons from each other while further strengthening strategic partnerships.

China probably will play the climate change card, but they would have used other cards to buy influence, so climate change won't change the China risk problem very much. it mainly just changes the rhetoric. If anything. by talking up the climate change 'crisis', Defence might be playing China's game.

Search and rescue

Defence also makes a search and rescue capability pitch.

Furthermore, the environmental impacts of climate change on the ocean and marine life, particularly in the Pacific and in the Southern Ocean, could see fishing vessels operating in new areas, including in international waters and New Zealand's expansive search and rescue area of responsibility in the coming years.

There is no evidence, of course, to support this contention.

Following from its identification of an emerging climate crisis, Defence lists a set of actions to improve climate change readiness. Amongst other things

- *Defence should start planning for increasingly concurrent operational requirements in the South Pacific due to the impacts of climate change.*
  -This could include updating the suite of Defence planning scenarios to enable preparation for increasing humanitarian assistance and disaster relief and stability operations as well as search and rescue in new areas due to anticipated changes to where fishing vessels operate.

We hope that they actually read the science as part of this exercise.

- *Defence should seek to elevate international discussion on the security impacts of climate change, including with foreign partners in bilateral defence talks and at regional forums. This would help Defence learn from others, highlight the impacts on the South Pacific, and emphasise the importance of improving resilience in the region.*

Again, it would pay to read the science first, or risk embarrassment in front of Australian and US defence personnel who won't be so much into climate change crisis hysteria.

Part nine: Direct interventions in the vehicle market

The Government has just released its 'Clean cars' proposals to reduce C02 emissions. There are two limbs of the proposals. First there are limits on the average emissions of the imported fleets of cars with financial penalties for compliance. Second, is a 'feebate' scheme which essentially involves taxing imports of higher emmission vehicles and using the proceeds to more subsidise more fuel efficient cars (particularly EVs, which will get a was favourably reviewed by the Productivity Commission in their 2018 Low Emissions Economy report.

We reviewed the analysis in the draft Productivity Commission report and made a submission pointing out the many flaws in their analysis, in particular those relating to a 'feebate' scheme. This is an inefficient tax on the poorer members of society to subsidise electric vehicle purchases by the better-off and corporate virtue signallers. Our submission is presented in appendix 3.

The proposals and the consultation paper came out too late to be fully analysed for this submission, but we will release a full analysis of the consultation document shortly. Briefly our take on the report is that it is badly thought out, poorly documented and not entirely honest.

- The Transport Ministry says that its 'preliminary' assessment is that the proposla have very positive benefit/cost ratios, but there is no sight of the analysis backing this assessment in the consultation document
- A significant impact on emissions is reported, but again, there is no sight of any analysis backing this claim.
- There was no analysis of alternative policies to reduce emissions.
- The winners will be well-off purchasers of EVs. The losers will be working families, who will find that the price of the $8000-$10,000 Japanese imports that they depend on for affordable transport, could increase by $2,000 -$3,000.
- Limiting the subsidy to EV's costing less than $80,000 is meant to mitigate equity concerns. Yeah right.
- The 'Clean car' initiative may be mis-named. It will encourage the importation of diesel cars, which are regarded by some as a dirty form of transport.

The MFE on barriers to electric vehicle uptake

The policy decisions may have been influenced by the MFE's perspective on the slow uptake of electric cars. In a recent paper *'Reducing barriers to electric vehicle uptake*

Behavioural insights: Analysis and review' the MfE argues that electric cars, are, on a lifetime basis, no more expensive than ICEs, and that low uptake is partially due to behavioural biases that lead to a form of 'irrational' decision making. There is a 'market failure' that provides the theoretical justification for intervention.

The paper discusses a number of impediments to EV uptake. 'Range anxiety' is described as a 'perceptition' problem that can be addressed by different ways of dealing with an exaggerated fear of running out of charge. However, for new cars this issue is rapidly becoming less relevant with new models coming on the market with ranges of 300-500 km., compared to around 100 km. for early model used Nissan Leafs.

Another issue is battery life. The review suggests that this can be addressed by letting people know that some manufacturers are offering warrenties of up to eight years on batteries, ignoring the fact that the used imports that dominate the market are not covered by manufacturers' warrenties.

The most important issues are price of new vehicles, and the availability of cheaper used electric car imports.

New EVs are significantly more expensive than equivalent ICE vehicles at present. Our findings indicate this is the biggest barrier to EV uptake globally and in New Zealand. However, a total cost of ownership or five-year running cost approach shows that new EVs are the same price or cheaper than equivalent ICE vehicles.

Concept Consulting (2016) estimated the price difference between a new mid-range EV over an equivalent new ICE vehicle was around $12,000 in New Zealand.

The Concept Consulting analysis was, put bluntly, faked. There was no evidence that the gap between new EVs and ICEs was around $12000 in 2016. Although there were few direct comparators then the real figure was closer to $30,000. In 2019 we have better comparison points. A new Nissan Leaf is priced at $59,000 for what is a $30,000 car. There is a direct comparson for the Hyundai Kona. The ICE price is $32000. The electric version is $72000. And the Volkwagen Golf EV is at least $25000 more expensive that its ICE equivalent.

And on running costs.
On the other hand, the running and maintenance costs are typically lower than for equivalent ICE vehicles, making the total ownership cost reasonably similar (Element Energy, 2013; Raustad, 2017).

The Element Energy comparison was for the UK and included a string of subsidies for EVs. It is not relevant to New Zealand. The Rousted analysis was for the US and included the large US Federal subsidy, and what appears to be an insurance break for electric cars. It is also not relevant.

The present value of the lower running costs (partially due to the road user charge subsidy) of an EV, offsets just a part of the new car cost difference. For example a new car buyer who buys a Corolla hybrid for $32,000, (or $29000 for a Prius C) with fuel consumption of about 4.1 litres per 100 kilometres, would have a fuel bill of less than $1200 a year (driving 12,000 kilometres), or $6000 over the MfE's five year total cost comparison horizon. The Corolla hybrid has carbon emissions of under 100 gms per kilometre, so emits 1.3 tonnes of carbon per year. The cost per tonne of carbon emissions saved from buying an EV (over the life of the vehicle) would be about $2000. A 'rational', environmentally conscious, car purchaser would buy the hybrid and then buy carbon credits at $25 a tonne. By investing in carbon foresty he could reduce net carbon emissions by a factor of 80 for the same money.

The MfE then argues that the price of EV's will fall in the near future.

Prices are projected to fall, with many vehicle manufacturers committing to reduced EV prices. For example, by 2022 Skoda intends to produce an EV with a 480-kilometre driving range and 15-minute charging time that is cheaper than most comparable ICE vehicles. But despite falling prices and the growing second-hand import market in New Zealand (Zhu, 2016), the perception remains that EVs are expensive.

If prices do fall then consumers will buy more of them, but this does not demonstrate that consumers are being 'irrational' now. Quite the opposite. If prices are forecast to fall, then it doesn't make sense to buy now because the price falls will be reflected in a higher depreciation rate for a vehicle purchased now.

Used EVs

The discussion then moves to used electric cars. These are much cheaper, because the initial japanese buyer (most used EVs sold in New Zealand are used Nissan Leafs) has incurred a very big loss.

On the second-hand market the 2011 Nissan Leaf is on average available for roughly $13,700 and the 2011 Toyota Corolla for roughly $13,200.

The MFE then does some calculations to demonstrate that the 2011 Leaf is significantly cheaper–by $1460 a year - to run over a 5 year horizon. It is then acknowleged that battery life may be a concern, and that the consumer may wish to buy a 2016 model. At an average price of $23,650 the Leaf is described as being

comperablely priced to the Toyota Corolla ($20943), the Mazda 3 ($23664) and the Ford Focus ($23259). We checked the MfE's numbers (on Trademe for prices) and found that there were biases that overstated the advantage of EVs.

- Fuel savings are overstated because the average mileage for all New Zealand cars is unlikely to be achieved by the average EV driver.
- No account is taken of much higher electricity prices at charging stations.
- The price of the Leafs is understated and that of comperable ICE cars overstated. The correct ICE compartors would have been used Japanese imports. The going rate for a standard 2011 Mazda Axela (the japanese version of the Mazda 3) is more like $10,000-11,000 than $13,000, and $19,000 for a 2016. The median price for a 2016 Leaf was $26000, $2,400 higher than the MfE's estimate.
- Electricty is priced at an off peak price of 0.15 cents per kilowatt hour. Not all home charging can be done at that rate.
- The expiry of the roaduser charge concession in 2020 is not taken into account.

The sunk cost fallacy

Another impediment to EV purchases, and an explanation of why New Zealanders tend to have older cars , according to the MfE, is the 'sunk cost fallacy'. People don't update their car because they become irrationally fixated on recovering their purchase price.

For example, imagine a buyer who bought an ICE vehicle three years ago for $11,000, but due to depreciation the vehicle is worth $6,755 in the current market. The buyer, however, still values the vehicle at $11,000 because they want to recover the money they initially spent. The vehicle is reliable and still meets their travel needs. The buyer may prefer to hold onto their vehicle until it no longer reliably meets their needs or repair costs exceed its value, rather than accept $4245 less than they value their vehicle at.

This reasoning (the sunk cost fallacy) *can apply to the purchase of an EV. Some buyers may find it difficult to justify the high upfront price for a number of reasons, including that they:*
• have 'sunk' so much into their ICE vehicle
• know their ICE vehicle has always been reliable
• do not have this level of trust with an EV (familiarity bias).

… this fallacy is likely to be a significant factor in slow EV uptake among the 84 per cent of New Zealanders who are not willing or able (constrained capital) to spend $30,000 on their next vehicle until EVs become considerably cheaper.

Most of this is overstated or wrong. New Zealanders do know that cars are a depreciating asset. But many just have a buy and hold strategy. It is perfectly rational to buy, say, a Toyota Corolla, when it is ten years old and keep it for another ten, or even fifteen, years while it continues to perform reliably. It may be a little less

fuel efficient than a later model, and have fewer bells and whistles, but this can be the lowest cost strategy. Turning over cars frequently, incurs higher depreciation, funding and tranaction costs (dealers' margins). Holding on to a reliable car also removes the risk of buying a dud.

However, the MfE 's basic point, that used EVs are more affordable than new vehicles, stands. There is not too much of a price penalty for being a 'climate warrior' or 'early adopter', as long as you don't mind the inconvenience of the EV on long trips; don't regard the Leaf as bug ugly; don't need a SUV, a people mover or a vehicle with some towing capacity.

So the MfE asks why aren't people buying EVs, and how can we reduce those impediments? The answer is that people are buying them. There are currently around 1000 Leafs for sale on Trademe and Leafs were the driver behind the upsurge in EV registrations in 2018. There are specialist EV dealers who are vigouously promoting them.

The MfE might repond that if we further encouraged EV uptake then even more will be sold. The basic flaw in that argument is that there is limit on the supply of second hand Leafs in Japan. Below are the numbers for Japanese Leaf registrations by year. Obviously not all are on sale, and New Zealand has already taken a fair chunk of the older ones. Other right hand drive countries, trying to their bit for the environment, are also accessing the used Leaf market. Sri Lanka has 5,000 Evs, most of them used Leafs. While efforts to further subsidise or promote EV sales will give New Zealand a bigger share of the finite pie, this will tend to drive up prices and some of the New Zealand subsidy would flow to Japanese sellers. The marginal cost per tonne of carbon saved could be very expensive.

Nissan leaf sales in japan Source: inside Evs

2011 10330
2012 11115
2013 13021
2014 14177
2015 9057
2016 14795
2017 16935
2018 25722

Is an old fleet a problem?

There is flavour in vehicle emission discussions that New Zealand's relatively old fleet (14 years compared to 10 years in Australia and the US, and 8 years in the richer

European countries) is a bad thing, and indicative of some kind of market failure. Some of the reasons that New Zealanders have older cars are:

- Cars are now more mechanically reliable and do not rust out, so they can be be kept for longer.
- New Zealand is a relatively poor upper income country. Fewer people cn afford a late model car. However, ordinary working people can afford a $8000 used importcar that will be reasonably reliable, without taking out an expensive loan that potentially can get them into budget difficulties.
- There is a large supply of cheap Japanese used car imports, which is not is not an option in countries that drive on the other side of the road, and for Australia, that banned them to support its car industry.
- Older cars are driven less than new cars so fuel economy is less of a consideration.
- New Zealanders may not place as much value on a new car as a status symbol as car owners in other countries.
- New Zealanders may be taking a circular economy approach (before the notion became fashionable) to car ownership. Cars should be used as long as possible.

Conclusion

The market appears to be working. Potential buyers are not being systematically irrational, and the market doesn't need further government intervention. There is limited scope for increasing the uptake of electric vehicles until the price of new vehicles falls, and there is a marked increase in EV sales in Japan, to fuel (with a lag) the second hand market. The immediate signs from Japan are not encouraging. EVs sales in Japan seem to be stuck at 1 percent of the market with total sales falling slightly in 2018.

The EV revolution is gathering pace, but it will be some time before there is a meaningful surge in EV purchases in New Zealand. However, EVs are a highly visible sign of the zero carbon transition and the Government has been tempted to tinker.

We should have resist the temptation to become another Norway, which, with a smaller fleet size, has more than 200,000 EVs compared to our 14,000. But that was bought at a very high cost. A range of subsidies reduced the cost of an EV to below the cost of an equivalent ICE. We haven't seen an estimate of the total cost but it must be in the order of $5-6 billion. We already have better beaches and flightless birds than Norway, so we should leave it to them in the EV competition stakes, contenting ourselves with the fact that we have more EVs than Australia.

Part ten: Cheaper ways to influence world opinion

As discussed above, one of the purposes of ambitious and early action is to get favourable attention internationally, which hopefully will add momentum to the international community's journey to a zero emmission world.

There are much cheaper ways to secure these benefits. We have set out five possibilities. Some are a little whimiscal, and are there to promote debate and thinking on other possibilities. Most are serious.

Higher carbon tax on vehicle fuel

The carbon tax on tranport fuels could be increased immdiately to, say, $50 per tonne of CO2, with futher increases to $100 and above signalled. This will not make a huge difference to fuel prices immediately, but we would have the highest carbon price in the world. Fuel pricing has the following advantages:

- It impacts on all fuel users not just on the purchasers of imported vehicles.
- It directly targets the problem. Drivers who drive more and more aggressively will pay more. Vehicle pricing is a poor way to target actual emissions.
- It does not involve a tranfer from working families to the relatively rich who can afford an electric vehicle.
- It better preserves consume choice
- It does not a require complex new administrative framework.

A tax on international air travel

International air travel emissions have been pretty much ignored in the New Zealand policy discussions. But New Zealand must have one of the most emissions intensive international tourist industries in the world, and New Zealander's have a high rate of long distance travel.

If we moved early to impose a significant tax on international travel, that would attract favorable international attention and may induce other countries to follow. It would reduce the incongruity in the argument that New Zealand needs to be carbon neutral to enhance our clean and green image, and so benefit the tourist industry.

We could impose a departure tax, which could be calibrated to roughly reflect a realistic CO2 price. There could be two prices, say $150 for long haul and $50 for the

Pacific and Australia. Alternatively, a tax could be levied on jet fuel. Airlines have a limited ability to avoid this tax by fuelling before getting to New Zealand.

The objections are that it would reduce tourist arrivals who would we more inclined to travel to destinations that don't impose the tax, or divert outward travel through Australia. On the last point, the diversion would be expensive, so the effect might be limited, but in any event, $50 is better than nothing.

There will be an impact on tourist numbers, but that is the point of the tax. The negative volume impact would likely be offset by the revenue benefits.

From a pure tax perspective, an exit tax is relatively efficient because more than half of the cost would fall on foreigners, whose welfare does not count from a New Zealand perspective. With respect to New Zealanders the tax would be largely progressive, compared to the regressive element in many other proposals. It would also offset part of the distortion in the tax system because international travel does not incur GST.

A ban on official business class air travel

A business class traveller generates three times the emissions of an economy class traveller. A single business class fare to London can generate 15 tonnes of CO2 (adjusting for the effect of high altitude emissions). There should be an absolute ban on business class travel by all government officials (including politicians). This has several advantages.

- It would get international attention.
- It would be domestically popular. Most people would support a policy that would require politicians and bureaucrats to put their butts where their mouths are. This would promote social solidarity.
- It would save money.
- It would reduce incentives to go on junkets.

A ban on travel to climate change conferences

The technology exists to attend a conference virtually**.** New Zealand would send a signal that it was serious about climate change by using this technology to reduce emissions from international travel. This would have the co-benefits mentioned above. It would also address a divergence between social and private benefits. The policy elite that attends these conferences gets a private benefit from mixing with likeminded colleagues. The need to gain social acceptance may bias their judgments to the detriment of New Zealand interests.

Replace the BMW 7 series ministerial cars with Nissan Leafs.

These will be cheaper (new price a just under $60,000) than the current BMW 7 series, and will set the right example from a social cohesion perspective. This is a ‘win-win’ initiative.

All tuk tuks electric

All tuk tuks should be electric by 2020. We will beat India (which already has 1.5 million electric tuk tuks) in the race to have a fully electric fleet.

Appendix 1 The Westpac Model

The Westpac Climate report is introduced on its website by the following bold headline and key result.

'Inaction on climate change puts tens of billions of dollars at stake.

Taking faster action on climate change could save New Zealand $30 billion by 2050, according to new research commissioned by Westpac.

The research, which was carried out by EY and Vivid Economics, was based on the modelling of two scenarios: a central scenario, where early climate change action is taken, and a shock scenario. The key difference between the two is that in the central scenario, agriculture is gradually introduced into the emissions trading scheme over 2020-30. In the shock scenario agriculture is introduced to the scheme in 2030, because some explained shock event occurs, and is only given two to five years to adjust to its full impact.

According to the report the early but slow introduction reduces agricultural output by 2.1 percent, compared to a 13.7 percent reduction with the shock event. This appears to the key to the reduction in GDP of 0.4 percent, (see their figure 1) which drives the cumulative $30 billion loss (which is reported in nominal rather than present value terms). The results look to be implausible and contrived. Technically the agricultural sector can do little to adjust to carbon prices over the next ten years, other than by reducing output, so it is not clear how the longer phase-in time would have helped. And if the phase-in time was critical, it is not explained why any sane government would impose the EPS over a two to five year horizon. Despite the criticality of these questions there is no discussion on them in the report.

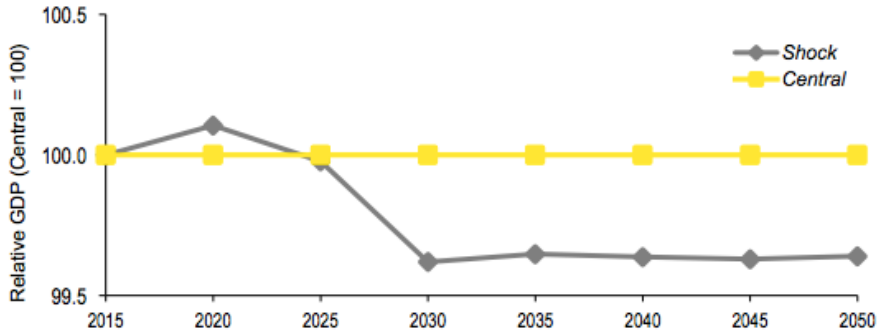


Figure 1: GDP growth (modelled at 5 year intervals) is steadier in the *central scenario* than the *shock scenario*

Source: Vivid Economics with EY analysis from ViEW CGE model outputs

A possible explanation for the results is that they might be partially driven by tougher emissions targets in the shock scenario. Their figure 2, presented below, appears to show that the 2050 emissions and the cumulative emissions are both lower for the shock scenario. Tougher emission targets will have a greater impact on GDP.

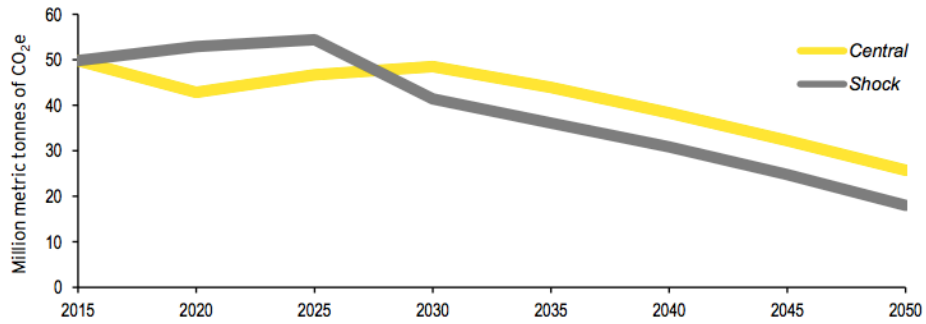
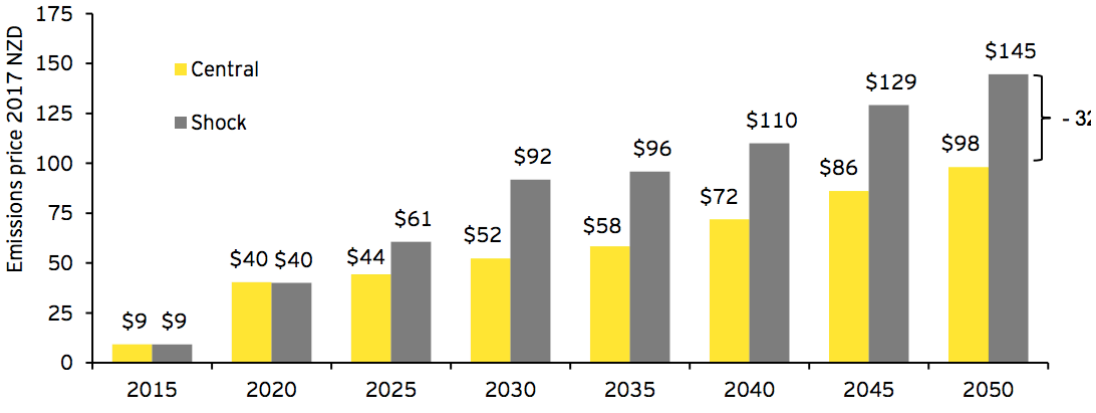


Figure 2: The scenarios differ according to their profiles of domestic emissions (modelled at 5 year intervals) and when agriculture is subjected to an emissions constraint.

Source: Vivid Economics; EY analysis from ViEW CGE model outputs

Another unexplained result is the emissions price time path. The prices are the same in 2020 and the shock price is higher in 2025 ($61 compared to $44) despite farming being in the ETS. The demand for units from the farming sector should require a higher price in the central scenario. There must be something else going on in he model that has not been disclosed.



In short this is an opaque model with implausible results, that appears to have been contrived to meet the clients needs.The Chief executive of Westpac is a something of a climate change activist. The model results should be ignored, at least until the results are better explained.

Appendix 2 The Fifth IPCC report on New Zealand

Observed and projected climate trends

Natural climatic variability is very high in the region

This variability poses particular challenges for detecting and projecting anthropogenic climate change and its impacts in the region. For example, changes in ENSO (El NINO/Southern Oscillation*) in response to anthropogenic climate change are uncertain (WGI AR5 Chapter 14) but, given current ENSO impacts, any changes would have the potential to significantly influence rainfall and temperature extremes, droughts, tropical cyclones, marine conditions, and glacial mass balance (Mullan, 1995; Chinn et al., 2005; Holbrook et al., 2009; Diamond et al., 2012; Min et al., 2013).*

The region has exhibited warming to the present (very high confidence) and is virtually certain to continue to do so (Table 25-1). Observed and CMIP5-modeled over 1950–2004 increases in annual rainfall in the south and west of the South Island and west of the North Island of New Zealand, and decreases in the northeast of the South Island and east and north of the North Island. …. For New Zealand, annual average rainfall is projected to decrease in the northeastern South Island and eastern and northern North Island, and increase in other parts of the country (medium confidence).

New Zealand extreme one-day events decreased in the north and east and increased in the west since 1930.

Projected magnitude of temperature extremes
Spring and autumn frost free land to at least triple by 2080
Up to 60 more hot days +25 degrees in the north by 2090

Comment: Other country reports typically focus on days exceeding 40C. The New Zealand test is more a measure of the increase in pleasantly warm, than extremely hot, days.

Drought
Time spent in drought in eastern New Zealand is expected to double or treble by 2040.

On the frequency of observed droughts there is no comment. Instead it is explained how a drought is defined.

Wind
mean westerly wind projected to increase….. decreases of 20% in Summer and Autumn
Fire risk

Changes in high and extreme fire risk days by 0-400% using one model 0-700% another by 2040.

Precipitation intensity

Increase in precipitation intensity of rare intense high rainfall events (low confidence)
Increase of daily extreme rainfalls of 8% per degree of warming

Comment: If temperature increases by 2 degrees then extreme daily rainfall events increase by 16 percent. This is not really a world changing outcome, but an increase in extreme rainfall events is often cited as a major climatic risk. Restricting the temperature change to one degree doesn't make much difference. There is low confidence in the intensity of intense rainfall events.

Tropical cyclones and other severe storms

Increase in intensity of cyclones in the south in winter but decreasing elsewhere.

Increase in conditions conducive to convention storm development is projected to increase by 3-6 percent by 2070-2100 compared to 1970-2000.

Comment: An increase in severe storms is often cited as an important driver of climate change costs. The increase, if any, is expected to be minimal.

Projected Impacts

Freshwater resources

In New Zealand precipitation changes are projected to lead to increased runoff in the west and south of the south island and reduced runoff in the northeast of the south island and the east and north of the north island Annual flows of east flowing rivers with headwaters in the southern alps are projected to increase by 5 to 10%. Retreat of the glaciers has only a minor effect.

In New Zealand a single study projects ground water recharge in the Canterbury Plains to decrease by 10 percent by 2040.

In New Zealand there is little evidence of water resource adaptation specifically to climate change. Water in New Zealand is not a scarce resource generally and water policy reform is generally driven more by pressure to maintain water quality while expanding agricultural activities.

Impacts of climate change on water supply, demand, and infrastructure have been considered by several New Zealand local authorities and consultancy reports (Jollands et al., 2007; Williams et al., 2008; Kouvelis et al., 2010), but no explicit management changes have yet resulted.

Inland freshwater and terrestrial ecosystems

In New Zealand, few if any impacts on ecosystems have been directly attributed to climate change rather than variability. Alpine treelines in New Zealand have remained roughly stable for several hundred years despite 0.9 degrees C average warming over the past century.

The few studies of climate impacts on biodiversity in New Zealand suggest that ongoing impacts of invasive species and habitat loss will dominate climate change signals in the short to medium term but that climate change has the potential to exacerbate existing stresses. There is limited evidence but high agreement that the rich biota of the alpine zone is at risk through increased shrubby growth and loss of herbs, especially if combined with increased establishment of invasive species. Some cold water-adapted freshwater fish and invertebrates are vulnerable to warming and increased spring flooding may increase risks for braided river birds. For some restricted native species suitable habitat may increase with warming although limited dispersal ability will limit range expansion. Tuatara populations are at risk of warming increases in the ratio of males to females, although the lineage has persisted during higher temperatures in the geological past.

Biodiversity research and management in New Zealand to date has taken little account of climate related pressures and continues to focus largely on managing pressures from invasive species and predators, freshwater pollution exotic diseases and halting the decline in in native vegetation.

Coastal and Ocean Ecosystems

No climate change impacts have been reported at this stage, although this may be due to insufficient monitoring.

Even though evidence of climate impacts on coastal habitats is limited to date, confidence is high that negative impacts will arise with continued climate change (Lovelock et al., 2009; McGlone and Walker, 2011; Traill et al., 2011; Chapter 6). Some coastal habitats such as mangroves are projected to expand further landward, driven by sea level rise and exacerbated by soil subsidence if rainfall declines (medium confidence; Traill et al., 2011), although this may be at the expense of saltmarsh and constrained in many regions by the built environment (DCC, 2009; Lovelock et al., 2009; Rogers et al., 2012). Estuarine habitats will be affected by changing rainfall or sediment discharges, as well as connectivity to the ocean (high confidence; Gillanders et al., 2011). Loss of coastal habitats and declines in iconic species will result in substantial impacts on coastal settlements and infrastructure from direct impacts such as storm surge, and will affect tourism (medium confidence; Section 25.7.5).

Comment: These are mostly qualitative, and somewhat shrill, assertions without any attempt to quantify the extent of the 'negative impacts'.

A strengthening East Auckland Current in northern New Zealand is expected to promote establishment of tropical or subtropical species that currently occur as vagrants in warm La Niña years (Willis et al., 2007). Such shifts suggest potentially substantial changes in

production and profit of both wild fisheries (Norman-Lopez et al., 2011) and aquaculture species such as salmon, mussels, and oysters (medium confidence; Hobday et al., 2008; Hobday and Poloczanska, 2010). Ecosystem models also project changes to habitat and fisheries production (low confidence; Fulton, 2011; Watson et al., 2012).

Comment: Here we have suggestions of 'potentially subtantial changes in production and profit' but no actual analysis to back it up.

Production forestry

In New Zealand, temperatures are mostly sub-optimal for growth of P. radiata and water relations are generally less limiting (Kirschbaum and Watt, 2011). Warming is expected to increase growth in the south and reduce it in the north but CO2 fertilization may offset this (medium confidence;

the above studies provide limited evidence but high agreement of potential net increased productivity in many areas, but only where soil nutrients are not limiting. Adaptation strategies include changes to species or provenance selection toward trees better adapted to warmer conditions, or adopting different silvicultural options to increase resilience to climatic or biotic stresses, such as pest challenge Agricultural production is sensitive to climate (especially drought; Box 25-5) but also to many non-climate factors such as management, which thus far has limited both detection and attribution of climate-related changes

Agriculture

Agricultural production is sensitive to climate (especially drought; Box 25-5) but also to many non-climate factors such as management, which thus far has limited both detection and attribution of climate-related change.

Projected changes in national pasture production for dairy, sheep, and beef pastures in New Zealand range from an average reduction of 4% across climate scenarios for the 2030s (Wratt et al., 2008) to increases of up to 4% for two scenarios in the 2050s (Baisden et al., 2010) when the models included CO_2 fertilization and nitrogen feedbacks.

Studies modeling seasonal changes in fodder supply show greater sensitivity in animal production to climate change and elevated CO_2 than models using annual average production, with some impacts expected even under modest warming (high confidence) in both New Zealand (Lieffering et al., 2012) and Australia

In New Zealand, projected changes in seasonal pasture growth drove changes in animal production at four sites representing the main areas of sheep production (Lieffering et al., 2012). In Hawke's Bay, changes in stock number and the timing of grazing were able to maintain farm income for a period in the face of variable forage supply but not in the longer term.

In Southland and Waikato, projected increases in early spring pasture growth posed management problems in maintaining pasture quality, yet, if these were met, animal

production could be maintained or increased.

The impact of elevated CO_2 on forage production, quality, nutrient cycling, and water availability remains the major uncertainty in modeling system responses (McKeon et al., 2009; Finger et al., 2010);

New Zealand agro-ecosystems are subject to erosion processes strongly driven by climate; greater certainty in projections of rainfall, particularly storm frequency, are needed to better understand climate change impacts on erosion and consequent changes in the ecosystem services provided by soils (Basher et al., 2012).

Cropping

Modeling suggests there is the potential to increase New Zealand wheat yields under climate change with appropriate choices of cultivars and sowing dates (high confidence; Teixeira et al., 2012).

Widespread drought in New Zealand during 2007–2009 reduced direct and off-farm output by about NZ$3.6 billion (Butcher, 2009). The 2012–2013 drought in New Zealand is estimated to have reduced national GDP by 0.3 to 0.6% and contributed to a significant rise in global dairy prices, which tempered even greater domestic economic losses (Kamber et al., 2013). Drought frequency and severity are projected to increase in many parts of the region

Energy supply demand and transmission

New Zealand's predominantly hydroelectric power generation is vulnerable to precipitation variability. Increasing winter precipitation and snow melt, and a shift from snowfall to rainfall will reduce this vulnerability (medium confidence) as winter/spring inflows to main hydro lakes are projected to increase by 5 to 10% over the next few decades (McKerchar and Mullan, 2004; Poyck et al., 2011). Further reductions in seasonal snow and glacial melt as glaciers diminish, however, would compromise this benefit (Chinn, 2001; Renwick et al., 2009; Srinivasan et al., 2011). Increasing windpower generation (MED, 2011) would benefit from projected increases in mean westerly winds but face increased risk of damages and shutdown during extreme winds (Renwick et al., 2009).
Climate warming would reduce annual average peak electricity demands by 1 to 2% per degree Celsius across New Zealand.

Tourism

Ski tourism is expected to decline in the Australian Alps due to snow cover reducing more rapidly than in New Zealand (Pickering et al., 2010; Hendrikx et al., 2013) and greater perceived attractiveness of New Zealand (Hopkins et al., 2012).

Human health

In the southern states of Australia and parts of New Zealand, this (heat related deaths) *may be partly offset by reduced deaths from cold at least for modest rises in temperature.*
Comment: This information comes from a study that examined the impact on mortality of heat and cold. It was based on empirical data from Christchurch prior to

2000. It was claimed that almost all of the winter excess mortality was due to air pollution not cold, and that cold only became a factor with temperature below 0C, and that heat was a factor above 28C. It is not consistent with many studies that find a relationship between cold and excess mortality at higher temperature thresholds.

Intra-and Inter-regional Flow-on Effects among Impacts, Adaptation, and Mitigation
For New Zealand, there is limited evidence but high agreement that higher global food prices driven by adverse climate change impacts on global agriculture and some international climate policies would increase commodity prices and hence producer returns. Agriculture and forestry producer returns, for example, are estimated to increase by 14.6% under the A2 scenario by 2070 (Saunders et al., 2010) and real gross national disposable income by 0.6 to 2.3% under a range of non- mitigation scenarios (Stroombergen, 2010) relative to baseline projections in the absence of global climate change.
Some climate policies such as biofuel targets and agricultural mitigation in other regions would also increase global commodity prices and hence returns to New Zealand farmers (Saunders et al., 2009; Reisinger et al., 2012). Depending on global implementation, these could more than offset projected average domestic climate change impacts on agriculture

Few studies consider mitigation benefits explicitly for New Zealand, but scenario-based studies give high confidence that, if global emissions were reduced from a high (A2) to a medium- low (B1) emissions scenario, this would markedly lower the projected increase in flood risks (Ballinger et al., 2011; McMillan et al., 2012) and reduce risks to livestock production in the most drought-prone regions (Tait et al., 2008a; Clark et al., 2011)

Migration within countries, and from New Zealand to Australia, is largely economically driven and sustained by transnational networks, ***though the perceived more attractive current climate in Australia is reportedly a factor in migration from New Zealand*** *(Goss and Lindquist, 2000; Green, A.E. et al., 2008; Poot, 2009*). (Our emphasis).

Appendix 3 Direct interventions in the vehicle market

This paper was written as a submission to the Productivity Commission's draft Climate change paper. The Commission's response was to mask some of their sillier and misleading arguments (though several remained) in the final report, but they did not change their recommendations.

The Productivity Commission's recommendations on direct interventions to reduce light vehicle greenhouse emissions: A review

In its draft report 'Low Emissions Economy' the Productivity Commission recommended two additional policies to reduce greenhouse gas emissions from light vehicles.

- Limits on maximum permeated emissions for newly imported vehicles.
- A 'fee-bate' scheme, which would tax relatively high emission imports, and use the proceeds to subsidise vehicles with relatively low emissions.

This note reviews the arguments and evidence that supports these recommendations. We proceed by setting out the arguments and evidence in the report, commenting as appropriate.

Our key conclusions are:

- The standard of the analysis was poor. Much of it is 'cut and paste' exercise from a few favorable papers. More skeptical analysis was typically ignored; the content of some papers was misrepresented; and there was little critical scrutiny of what was used.
- The policies will not generate least cost abatement and could generate some perverse outcomes. The uptake of new electric vehicles will be encouraged at a cost of more than $1000 per ton of CO2 saved.
- The policies are heavily regressive. The poor will be taxed to subsidise the rich, and corporate virtue signalers.

It could be said that the Commission has been more concerned with cheer leading than providing robust and independent scrutiny of the proposals.

Setting the scene

The Commissions sets the scene by trying to convey a sense of the necessity and urgency for action.

The average age of vehicles rose 14.2 compared to 10 for Australia. Vehicles are scrapped after 19 years. This slow turnover implies that purchased in 2018 will likely stay in the fleet until well after 2030 and potentially after 2040.
Vehicles entering New Zealand's fleet are more emissions intensive than in many other developed nations.

All this is all true but not a surprise. By developed country standards we are relatively poor (more upper middle income than rich) and heavily rely on imports of older, cheaper, but more emissions intensive second hand vehicles. Vehicles are kept for longer periods because many motorists cannot afford to update to a more modern vehicle. Motorists also have places to park; there is a less of the dense urban environments that favor smaller cars; and more of an outdoors culture that favors larger ones. Our preferences and needs are different to those in Europe and Japan.

Reliance on road transport has led to significant external costs.
While there are some externalities, mostly (i.e. congestion) these are not relevant to the emissions issue. As discussed below the amount of relevant unpriced emissions related externalities is not as large as implied.

The obvious solution to unpriced externalities is to apply an appropriate tax on fuel. The emissions price component could be increased, with an additional tax applied to price the health effects of emissions. This has some obvious advantages compared to the Commissions proposals:

- It is easy to do. The pricing mechanism already exists.
- It applies to all vehicles. It will take around 20 years for policies applied to just newly imported vehicles to have their full effect. We conducted a 'back-of-the-envelope' assessment of the relative effectiveness of a 5 percent increase in petrol/diesel prices compared to an emission standard that improved efficiency of new imports by 15 percent. Over 20 years the price increase reduced emissions by a third more.
- It is more precisely directed at the externality problem, which is a function of how far a car is driven, and how it is driven, not just a measure of its emissions performance per kilometre under laboratory conditions.

The Commission appears to acknowledge the importance of an efficient pricing mechanism in principle, but argues that complementary policies are still necessarily and that reducing emissions will not come at a large cost.

At current prices the NZ ETS is likely to have a limited impact on transport emissions. The emissions price is a relatively small component of fuel prices at current levels, and fuel demand is relatively unresponsive to changes in price.

The current carbon price is about $25, but even if were doubled this would not make a huge, short run, change to the level of emissions. However, this does not necessarily lead to the conclusion that emission controls or subsidies are necessary.

It just means that personal transport is highly valued and that it may be more efficient if net emission savings are obtained elsewhere at a lower economic cost. If vehicle emissions look to be higher in 2050 than projected then the difference can readily be made up by more forestry sequestration, which is a relatively heap form of abatement.

More importantly, for this discussion, is the argument that there is an urgency to improve fuel economy right now. This case is not made. Emission controls and feebates might improve the fuel economy of imported cars, but these will have been scrapped by the target date of 2050. And while there may be some impact on cumulative emissions this can be readily achieved by alternative, much more efficient, mechanisms.

The case for Emissions Controls

To justify the interventions the Commission argues that there are market failures in the car market that, by implication, justify an emissions limit intervention.

First, motorists systematically underprice future fuel savings, and second, manufacturers do not provide New Zealand car buyers with the choice of the most fuel-efficient cars.

Even with much higher emission prices development and uptake of lower- emission vehicles will very likely occur more slowly that optimal from a societal perspective. Evidence suggests that buyers behave as if they heavily discount future fuel savings and that and that uncertainty around future fuel (and emissions) prices may play a role in this.

…. buyers can only act on the choices available to them, and are very unlikely to be aware of more efficient model variants unavailable in NZ.

Manufacturers will chose a selection of vehicles that will maximize their profits – Manufacturers are likely opting to provide less efficient model variants into the New Zealand market than to markets where standards apply

Obviously manufacturers are seeking to maximize profits, but in a small market where they cannot economically support every model variant, the expectation is that they will restrict themselves to a subset that best matches consumer demand. Further, the majority of New Zealand car registrations are used and parallel imports. It is perfectly possible for buyers to import more fuel-efficient models if they wish to do so.

Here the Commission's analysis is essentially a cut and paste from the Australian Department of Infrastructure and Regional Development's (DIRD) Regulatory Impact Statement (2016) on emissions targets, so we have set out the DIRD's key arguments to give the reader a better sense of the economic logic.

2.3 Government action could help address market failures
Market failures are departures from the characteristics necessary for unregulated markets to deliver outcomes that maximise both private (household and business) as well as overall (social) wellbeing (PC 2005, DPMC 2014). The most relevant market failure with respect to light vehicle efficiency is the amount and/or distribution of information in the market, and the ability to process this information.

Vehicle suppliers and buyers generally have asymmetric information about the costs of improving vehicle efficiency (Green 2010). Vehicle makers know the relationship between fuel efficiency and additional vehicle costs for a large range of technologies, including those not currently included in their vehicles, while vehicle buyers generally only know (and can act on) the trade-offs between vehicle costs and efficiency that are currently on offer.

If buyers undervalue efficiency improvements, or have limited capacity to assess the value of those improvements when making purchasing decisions, then manufacturers have less incentive to supply vehicles that maximise private or social wellbeing.

An important behavioral barrier is that any individual's ability to obtain and process complex, changing and uncertain information is finite. In response to complexity, rather than calculate the best possible private decision, individuals tend to adopt rules-of-thumb. Such strategies include purchasing the same brand as a friend, purchasing the same brand that they have bought before, or using simplified choice criteria that focus on a subset of the features of a good *(Green 2010).*

While these measures (fuel efficiency labeling) help consumers assess the relative efficiency of new vehicles and provide an incentive for consumers to consider the purchase of a more efficient vehicle, these measures do not address the difficulties consumers face in assessing the benefits of efficiency, relative to other attributes such as price, size and performance. As the benefits of purchasing a more efficient vehicle tend to be less immediate and tangible to consumers, this can make it less attractive for vehicle manufacturers to use efficiency as a selling point.

*While a recent survey found that Australians rate fuel efficiency along with reliability as the two most important considerations when buying a car (AAA 2016), there is very little evidence on how they assess the benefits of fuel efficiency–particularly over the longer term. Calculating the benefits from improved fuel efficiency requires both specific information and strong mathematical skills, and is unlikely to be done by all purchasers or for all purchases (see, for example, ABS 2013a**). Evidence from overseas markets such as the US indicates that buyers behave as if they heavily discount future savings from reduced fuel use*** (our emphasis, for its significance see below) (Green 2010, IEA 2012)

These behavioral barriers are likely to have a more pronounced effect on household rather than business vehicle purchases. Nevertheless, there is substantial evidence that similar barriers can also prevent businesses investing in cost-effective efficiency improvements, especially if fuel use is a relatively small component of overall costs (ClimateWorks 2013). For example, fleet buyers are likely to require payback periods of three years or fewer on a more efficient vehicle because most fleet vehicles are re-sold within this period. As just under half of new cars are purchased by fleets (FCAI 2015), this 'split incentive' could limit the take-up of vehicles that would deliver overall financial benefits for motorists but not their first owner (CCA 2014).

On the 'split incentive' problem, this ignores the fact that fuel economy is embedded in used car prices. Other things being equal, superior fuel economy increases the resale price of the vehicle, and reduces the initial buyer's overall vehicle costs. There is no a priori reason to expect that the market does not work in this respect.

And, as noted above, In New Zealand the majority of vehicles are used imports, and so consumers of used vehicles are not constrained by 'inefficient' choices made by domestic new vehicle purchaser.

Green (2010) is the source of most of the DIRD's analysis. This is what was actually said on the evidence that consumers systematically undervalue fuel economy.

The evidence from econometric studies, mostly from the US, is reviewed and shown to vary widely, providing evidence for both significant under- and over-valuation and everything in between.

The DIRD's representation of what Green et. al said was misleading. They did not say that the evidence indicated that buyers heavily discounted future fuel savings.

Green et. al. also discuss theoretical arguments on the role of risk and loss aversion in decision making. It is claimed that these factors coud imply that consumers might undervalue fuel economy relative to its expected value.

Market research is scarce, but indicates that the rational economic model, in general, does not appear to be used by consumers when comparing the fuel economy of new vehicles. Some recent studies have stressed the role of uncertainty and risk or loss aversion in

consumers' decision making. Uncertainty plus loss aversion appears to be a reasonable theoretical model of consumers' evaluation of fuel economy, with profound implications for manufacturers' technology and design decisions. The theory implies that markets will substantially undervalue fuel economy relative to its expected present value.

But they concludes by saying:

The theory of bounded rationality implies that if fuel prices are high enough to make fuel economy one of consumers' 3-5 top considerations, it may be considered in a manner closer to the rational economic model.

As fuel prices in Australia (and New Zealand) are much higher than in the US, and fuel economy is an important purchaser consideration in both markets, the conclusion that should have been drawn from Green is that these markets can be expected to be broadly efficient.

The Australian Productivity Commission on market efficency

In 2005 the Australian Productivity Commison (APC) produced a report (The Private Cost Effectiveness of Increasing Energy Efficiency) on the effiency of a number of markets where regulatory interventions were being contempalted. With respect to motor vehicles their key conclusions were as follows:

The Commission considers that the bounded rationality of consumers is an insufficient ground for justifying intrusive measures such as minimum standards. The case for intervention relies on notions of omniscient regulators who are capable of making decisions that are in the best interests of energy users. If those users were capable of collecting and digesting the relevant information, the presumption is that they would come to the same conclusion as the regulator, that is, to not purchase the energy-inefficient appliance. This might decrease search costs but given the diverse preferences of energy users, must inevitably leave some consumers worse off.

Whether reducing fuel consumption through greater fuel efficiency is privately cost effective will depend on the savings from lower fuel consumption compared to any capital cost of improving fuel consumption and the value to consumers of any other loss in amenity required to achieve those savings. The absence of any clear market failures impeding vehicle buyers from making privately cost-effective energy efficiency improvements suggests that opportunities for such improvements are limited.

The highly competitive nature of the Australian motor vehicle market should mean that producers provide the vehicle features sought by consumers, of which energy efficiency is one.

Fleetwide fuel-efficiency targets that go much beyond what the market would deliver are likely to suffer from a number of drawbacks. To the extent that such targets distorted producer and consumer behavior, the resultant energy efficiency gains would not be

privately cost effective — consumers would value improved fuel efficiency less than the associated costs and additional constraints on vehicle choice.

There is nothing in the DIRD's analysis that would lead to a different conclusion. Notably, the DIRD cited the APC's report, but did not explain why they came to such a different conclusion. Notably too, the Commission also cited the APC report but did not discuss it, or explain why they have came to a different conclusion.

The DIRD's cost benefit analysis

The Commission also cites the DIRD's cost benefit analysis, which purports to show that the benefits of fuel efficiency standards exceeds the costs, and that the costs of lower carbon emissions are therefore negative.

The Australian Government has modelled the impact of a light vehicle CO2 emission standard at different target levels. The modeling found net economic benefits under all targets considered. The current emissions intensity of NZs light vehicle fleet is very similar to Australia's so it is likely that similar results could be obtained.

The DIRD's methodology was as follows:

- The fuel costs savings from the projected improvement in vehicles efficiency was calculated.
- The value of the associated C02 reductions was calculated using a carbon price of A$35 per ton.
- The cost of meeting the higher targets were taken from US and European government studies of the higher manufacturing costs to meet emission standards in those countries. These estimates were described as uncertain.
- The costs and benefits are calculated annually out to 2040 and then expressed as present values.

The present value of fuel savings and carbon reduction benefits for the most stringent of three requirements were $27.5 billion and $2.7 billion respectively. The cost was $16.2 billion. As the financial benefits are higher than the costs there is a negative cost for reducing carbon emissions.

The obvious problem with this analysis is that the cost figures relate to large European and American manufacturers. However, the per unit cost of making any material technical innovations for the Australian market would be much higher. Manufacturers might do some minor tinkering, but the main response would be to withdraw product lines; or depending on market dynamics, raise prices for the less fuel-efficient models to choke off some of the demand. The presumption, as the APC has argued must be that these responses will have a net welfare cost. There will be a stronger presumption of a loss in the much smaller New Zealand market.

In short there is no free lunch here. The DIRD cost benefit analysis did not seriously engaged with the key issue, which is whether they can increase welfare by interfering with market processes. Obviously fuel consumption can be reduced by compelling people to drive smaller cars. But this comes at a cost because users value other vehicle attributes, not just fuel economy.

Another serious shortcoming in the Commission's analysis is the lack of any consideration of the impact of emission standards on the used import market, which account for more than half of vehicle registrations. There is a discussion of administrative difficulties in applying the standards to used imports. However, they do not consider the effect of the emission standards themselves on the functioning of the used import market.

The latest statistics show that average age of used imports is 10 years. There must be a significant risk that many older cars will not meet lower and increasingly restrictive efficiency standards, and that a material part of the supply will be choked off. Used imports are critical in supplying poorer New Zealanders with affordable transport, so the effect of the policies will fall disproportionately on them. They will have to pay more for a much newer vehicle, buy a car that is too small for their needs, or not update their car.

There will be unintended consequences:

- The introduction of the requirements will be well signaled, so there will be a rush to import vehicles before they come into effect. These vehicles will probably be less efficient than the vehicles that would otherwise have been imported at a later date.
- Some owners will respond to higher prices by deferring the replacement of, say, a twenty-year-old vehicle with an eight-year-old vehicle that is more reliable and fuel-efficient. The effect will be to reduce fuel efficiency.
- The road toll could deteriorate. One of the factors behind the improvement in the New Zealand road toll over many years was a shift from motorcycles to cars. This trend could be partially reversed.

The Commission acknowledges that there could be an impact on prices.

Introducing vehicle emission standards is likely to raise average vehicle prices over time. Yet the increase would be gradual given that the standards only effect new vehicles entering the fleet and most vehicles stay in the fleet for close to two decades.

This is wrong. Choking off the supply of used imports will quickly impact on prices through the second hand market.

On equity issues the Commission acknowledges that *the effect of any price increase would be felt particularly strongly amongst low-income householders.*

Their recommendation is that *'the government should monitor the effect over time'.* There is no suggestion that the equity effect should be a material consideration in the decision to introduce emission limits, or any suggestion of what the government should do to mitigate the equity impact.

The fee-bate scheme

A feebate scheme involves taxing high emitting vehicles and using the proceeds to subsidise low emitting vehicles. While the scheme applies to all vehicles (that meet the minimum emission standard), the primary intended effect will be to subsidise Electric vehicles (EV) imports, which the Commission wants to encourage, and to tax internal combustion engine (ICE) imports. Again it is argued that the scheme can be justified because it corrects for external costs generated by internal combustion engine vehicles.

A key rationale for providing incentives for EVs is that the actual cost of using EVs is currently greater than the wider social cost. Also consumers do not fully benefit from reducing social costs when switching from a fossil fuel vehicle due to currently lower emission price and the lack of pricing for air pollution.

In addition to the above C02 and air quality social costs, EV owners are also penalised because they do not pay the true social costs of electricity. They typically charge at night when the social cost is low, but incur the higher average cost applied to domestic consumers.

In response to the argument that the external cost issue can best be resolved by appropriate fuel pricing the response is that "*Electricity pricing will take time to resolve. Some form of support is therefore likely to be required as a transitional measure.*

There is already some form of support. EVs are exempt from road user charges. This could be continued, at an appropriate level, past the current expiry date of 2021. This subsidy does not precisely target the difference between private and social cost, as it is applied per vehicle, not by the amount of electricity used. In this respect it is close to identical to a fee-bate subsidy that similarly does not target actual usage. The road user charge subsidy will do as a 'transitional measure' until the electricity pricing issue can be addressed.

Are EVs already economically viable?

The Commission references analysis by Concept Consulting (CC) that suggests that EVs are already economically viable at current prices.

Concept Consulting 2017(a) demonstrate that with an emission price of just $9 EVs with a price premium of $12500 would be a viable option for consumes if the full public benefits of EVs were taken into account.

We have, approximately, replicated the CC analysis, which looks at whole of vehicle life costs and benefits including the costs of air and noise pollution. The critical assumption is the EV price premium. There is no explanation of where the $12500 (ex-GST) number comes from. It appears to be there just to make the numbers work.

Assessing the difference between EV and ICE prices in New Zealand has its difficulties, but the best comparison is the Nissan Leaf[39]. New or near new Leafs are sold on Trademe (without a manufacturer's warranty). One could be obtained at around $48000 ex GST. A new Toyota Corolla ICE vehicle might be a suitable comparator (excluding any adjustment for the EVs much inferior range, and longer 'refueling' time) costs around $25000. That is a difference of around $23,000. Looking at BMWs, the cheapest 1 series is $47000, the cheapest EV, the i3 hatch is $86000. BMW's are not a common purchase, so we have based our assessment on the Leaf price premium, using $20,000 and $25,000 price difference assumptions.

Another key assumption is the distance travelled. The shorter the distance, the less attractive the EV, as there is lower fuel savings to compensate for the higher capital cost. CC present different estimates based on the distance travelled. At 50 percent of the New Zealand fleet average, the carbon price that equalises the costs and benefits is $415 compare to the $9 for an average distance assumption. The Commission, however, focused on the average distance result.

Because the limited range of EVs we think that a lower distance travelled is the better assumption than the average. There is some evidence on this in Trademe's used car advertisements. The odometer reading for 2011-2012 used Corollas was 85000 km. For Leafs of the same vintage it was 35,000 km. Assuming that EV average mileage will increase in the future, as EVs with a longer range come on stream, we have assumed, somewhat generously, that average EV kilometers travelled will be about 60 percent of the average. We have also assumed that EVs will have an average life of 12 years due to battery degradation.

[39] New Leafs cost about $60,000. The best like for like comparison is the Hyundai Kona. It has a 60kw battery and a range of about 300 km. The iCE version costs $32,000 compared to $72000 for the electric version.

Given these assumptions our estimate of the cost of C02 saved per ton is about $1000, assuming a $20000 price differential, and $1400 assuming $25000.

These are whole of life calculation. For new car buyers who keep the car for 3 or 4 years the figures are substantially higher – over $2000 per ton, because heavy depreciation costs overwhelm fuel and 'external' costs savings over a short holding period.

It is clear that on a lifetime basis EVs are not a cost effective way to reduce C02 emissions. However, all is not lost for those who want to see to see an early EV uptake. New Zealanders can, and do, purchase imported second hand EVs. Because of heavy depreciation rates over the first three or four years, the capital cost for the subsequent purchaser will be much lower than the new price, while the owner benefits from lower running costs.

The uptake of used EVs is already occurring. On July 15 2018 there were 777 Nissan Leafs for sale on Trademe. Over 700 were used, and the great bulk would have been imports. Used imports now account for about 80 percent of EV registrations. It is possible that some of these vehicles may have a short and uncertain life, which would ruin the cost effectiveness of the purchase decision, but that is a risk that some buyers are prepared to take. For some there is utility in doing their bit to fight global warming, which outweighs narrower financial considerations.

Future prospects look positive. The range of available vehicles will widen, battery longevity should become more reliable; effective range is improving as battery sizes grow; and costs are likely to fall. As the stock of more reliable and longer-range second hand vehicles in Japan and the UK grows, more will find their way to New Zealand. But it is not at all obvious that this process should be accelerated now by applying a subsidy. Why further encourage New Zealand's use as a 'dumping ground' for suspect and obsolete EVs? Why should the buyer of a second hand internal combustion engine have to pay more for a vehicle to the benefit of EV purchasers, who are already rewarded through a virtue premium for doing their bit for the planet? Given the small stock of suitable used EVs for sale in the UK and Japanese markets, part of the subsidy to New Zealand buyers will flow through to sellers in those markets as increased New Zealand demand pushes prices up.

The equity issue

It is fairly obvious that the feebate scheme will be regressive. Private early adopters will almost certainly have higher incomes than conventional car purchasers. Companies, who are in the virtue signaling game, are perfectly capable for paying for the public relations benefit of being seen as early EV adopters. Air New Zealand, who

emits as much C02 as 1,000,000 cars, has committed to converting all of their light ground transport to EVs (where possible) by 2020. With a feebate scheme a struggling family in Porirura, who wants to upgrade a 20 year old car will have to help pay for an Air New Zealand' effort to deflect attention from their total C02 emissions.

The 'supporting' literature on feebates

The Commission cites three references to support their recommendation to introduce a feebate scheme.

In modeling pricing policies for vehicles in the United Kingdom Brand et al 2013 found feebates to be most cost effective in reducing emissions and accelerating the market share of EVs.

Brand et al. evaluated three policy options: feebates, road taxes and subsidised scrapping. They excluded a consideration of fuel pricing on the grounds that the public thought that these taxes were already too high. The assessment criteria were: which option delivered the greatest emissions reduction: revenue neutrality, and no adverse effects on car usage. There was no mention of economic efficiency. The scrapping scheme was assessed as relatively ineffective. The first two options were equally effective, but the tax option risked 'overburdening' the public with excessive taxes. Essentially their assessment was made more on political than economic grounds. If a tax can be hidden in a bundled proposal then it is more likely to be acceptable.

Element Energy recommended that the feebate should be explored.

A recommendation to 'explore' is not compelling support, or evidence.

Barton and Schulte identify feebates as a policy that has 'credibility' a proven record of success internationally, and is suitable for New Zealand.

There is no economic analysis in this paper. In particular there is no assessment of the economic costs and benefits, or any comparison with the price based policy option.

Why the need to encourage a rapid increase in EVs now?

The Commission argues

The earlier the uptake accelerates the greater the proportion of EVs in the fleet by 2050

This doesn't follow. The vehicles that are imported now will not be around in 2050. Given the likely rapid evolution in EV capability, and possibly, costs, and the need to wait until the stock of better used vehicles in the UK and Japanese markets builds, it makes sense to wait, and to let normal market processes work. There is no reason

to believe that this waiting period would affect the stock of EVs in 2050. Indeed there is a risk to promoting the early adoption of what are immature technologies.

A second argument is that *Early adoption would promote technology leaning.* It is not explained what this technology learning is, but this appears to be a trivial point. In terms of the actual driving the transition from conventional cars to EVs is straightforward. Drivers will also have to learn how to manage the short range of EVs, but this will become less relevant as the range of EVs improves.

Treasury on subsidies

A report by Treasury is cited. Treasury argues that the Road User Charge subsidy for EVs is poorly targeted. EVs use the roads so it is appropriate that they pay the tax. Instead Treasury recommends a price subsidy that directly targets the price differential between EVs and ICEs It is difficult to understand the logic here. EV buyers benefit from their purchase, so there is no obvious reason why a driver should be subsidised just because they have chosen a more expensive vehicle.

The health cost of air pollution from transport emissions

CC has usefully translated aggregate estimates of the health costs of emissions into per litre costs. Their starting point was two studies of the health costs of transport emissions in New Zealand:

Updated Health and Air Pollution in New Zealand Study", March 2012. This study estimated the human health costs of transport emissions to be $950m per year. Surface Transport Costs and Charges Study, March 2005. This study estimated the human health costs of transport emissions in 2001/2 to be $600m per year.

If both estimates are updated to a 'present value', taking into account increases in population and CPI since the estimates were calculated, this gives rise to a 2015/16 estimate of $1.1bn and $1.3bn, respectively. For the purposes of this study, a central estimate of $1.2bn/year is used. This cost has been simply apportioned between petrol and diesel vehicles in proportion to their relative emissions of PM_{10}. According to Ministry of Transport data on median PM_{10} emissions from light vehicles in Auckland, diesel vehicles emit approx. 6.5 times more PM_{10} than petrol vehicles.

Using this factor, and reported land transport diesel and petrol consumption for 2015, this gives rise to a health cost of 7 c/litre for petrol, and 44 c/l for diesel.

The CC approach does not adjust for motor vehicles emissions costs due to heavy vehicles, and so overstates the light vehicle costs. More importantly, there are some serious issues with the assumptions in the Health and Air Pollution study, which, in our view, potentially very substantially overstates the social cost of air pollution. This

is a complicated issue, which will be the subject of a forthcoming paper, but two important issues are straightforward enough to be presented here. The first issue relates to the social costs of a premature death.

Almost all of the social costs in the Health and Air Pollution study relate to premature deaths.

These deaths are heavily concentrated amongst the elderly.

It is assumed that the social cost of a death (taken from the road fatality social cost estimate) is not a function of age. That is, avoiding the premature death of an elderly person who might otherwise have lived for, say another three years, has the same social value as avoiding the premature death of a 15 year old, who would otherwise have lived for another 70 years. This is not a judgment that we, and we believe most New Zealanders, would share. If the methodology were adjusted to a number of life years saved basis, then the estimate of the social cost of air pollution would fall by perhaps 80 percent.

Second, the New Zealand study appears to substantially overstate the number of premature deaths due to air pollution. Their estimate was 2,300 per year. A recent World Health Organisation report's[40] estimate for New Zealand is 20.

Our conclusion is that social costs of air pollution have been exaggerated and reducing the costs caused by vehicles is too trivial a 'co-benefit' to warrant consideration. Even if it were more material, a tax of a cent or two on fuel would address the issue.

Conclusion

The Commission has not made a case for the introduction of emission standards for imported vehicles and the introduction of a fee-bate scheme. There is no evidence of material dysfunction in the car market that would warrant intervention, or of material external costs that can be mitigated by these direct interventions. The proposals are regressive. Poorer car owners will have their access to affordable vehicles reduced, and they will be taxed to subsidise middle class and corporate virtue signalers.

[40] WHO 2016 Ambient Air Pollution: A global assessment of exposure and burden of disease

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