David Hall and Robert McLachlan

Why Emissions Pricing Can't Do It Alone

Abstract

This article explores whether emissions pricing is sufficient to achieve the low-emissions transition in Aotearoa New Zealand. It draws on a critical review of the international literature on emissions pricing, policy interactions and political economy to make three broad arguments. First, that emissions pricing alone cannot be expected to induce the necessary levels of behaviour change and technological transition in the urgent time frame required. Second, non-pricing policies can deliver emissions reductions, even within the context of emissions trading under a volume cap. Third, even if emissions pricing could induce sufficient change, there are political economy constraints on reaching the adequate price in a feasible and equitable way. Consequently, we argue that the weight of evidence lies with utilising emissions pricing as part of a policy mix.

Keywords environmental economics, emissions trading, climate policy, climate justice, just transitions

David Hall is a senior lecturer in the School of Social Sciences and Public Policy, AUT University, and founding director of Mōhio's Climate Innovation Lab (www.mohio.co). **Robert McLachlan** is a distinguished professor in the School of Fundamental Sciences, Massey University, and writes on climate and environmental issues at planetaryecology.org and in other media.

There is strong agreement among economists that emissions pricing ought to play a central role in climate change policy. In the absence of emissions pricing, the climate impact of our choices as consumers, producers and investors is not reflected in market price signals, and behaviour is incentivised to contribute to damaging climate change (Aldy and Stavins, 2012). Among neoclassical economists in particular, emissions pricing is championed as the most efficient way to mitigate greenhouse gas emissions (Howard and Sylvan, 2015; Climate Leadership Council, 2019). This theoretical judgement is informed by the neoclassical commitment to maximising allocative efficiency and, therefore, favouring price signals over regulations.

As emissions pricing mechanisms are implemented around the world, there is an opportunity to match theory with empirical observation. Emissions pricing mechanisms are now implemented in at least 78 different jurisdictions; in 2021 a price will be paid on 22% of the world's emissions (World Bank, 2020). Perhaps the

Table 1: New Zealand's greenhouse gas emissions in 2016 and 2019, and target emissions in 2030
in million tonnes of co_2 equivalent

		2016	2019	% change	2030	% change
Carbon dioxide (CO_2)	Electricity	3.0	4.2	38%	1.3	-70%
	Food processing	2.7	3.2	20%	1.5	-55%
	All other industry	12.0	12.1	1%	9.4	-22%
	Buildings	1.6	1.8	11%	1.3	-24%
	Transport	15.0	16.2	8%	14.0	-14%
Gross CO_2 total		34.3	37.5	9%	27.5	-27%
Other long-lived gases	Agriculture	8.8	9.0	2%	8.0	-11%
	Forests	-13.8	-7.4	-46%	-11.6	57%
	Waste and fluorinated gases	1.8	2.0	11%	1.6	-20%
Net long-lived gases		31.1	41.1	32%	25.5	-38%
Biogenic methane	Agriculture	30.3	30.6	1%	27.1	-12%
	Waste	3.2	3.1	-5%	2.3	-26%
Gross all gases		78.5	82.2	5%	66.4	- 19%
Net all gases		64.7	74.8	16%	54.8	-27%

Source: McLachlan, 2021. Data for 2016 and 2019 emissions from UNFCCC, using AR4 emissions factors. The 2030 target emissions are extrapolated from the Climate Change Commission's (2021) demonstration pathway. 'Forestry' refers to LULUCF emissions using the Climate Chance Commission's 'NDC (averaging)' methodology.

most rigorous cross-country analysis is by Best, Burke and Jotzo (2020), who estimate that the 43 countries with a carbon price have on average had annual CO_2 emissions growth rates that are about two percentage points lower than those of the 99 countries without a carbon price, all else being equal. A review of the European Union emissions trading scheme, the world's longest running, estimates that emissions in energy and industry were reduced by 3.8% between 2008 and 2016 (Bayer and Aklin, 2020). The modest impact of emissions pricing is corroborated by other reviews and ex post evaluations (Haites et al., 2018; Narassimhan et al., 2018; Tvinnereim and Mehling, 2018; Rafaty, Dolphin and Pretis, 2020). Lilliestam, Patt and Bersalli (2020) and Green (2021) draw more pessimistic conclusions, while others argue that the impact of emissions pricing is constrained by its relative novelty and historically low prices (van den Bergh and Savin, 2021). In sum, the empirical record is incomplete and evolving, but corroborates the efficacy of emissions pricing instruments by demonstrating a modest, positive impact.

Still, even if we accept that emissions pricing is efficacious, is it *sufficient* as a policy response to climate change? Arguments to the affirmative are becoming increasingly adamant in Aotearoa New Zealand (Hartwich, 2021; Prebble, 2021; Hazeldine, 2021). What unifies these opinion pieces is, first, their shared appeals to a supposed economic consensus to justify the sufficiency of emissions pricing and, second, their claim that the Climate Change Commission should be disregarded, if not dismantled, for recommending a policy mix that goes beyond emissions pricing. However, this is inconsistent with domestic and international experience, and betrays a disconnect from the specialist literature on the applied economics of climate change. As we find in this literature review, there is no consensus on the sufficiency of emissions pricing and, if anything, the evidence leans towards the opposite conclusion.

The literature on policy mixes and interactions in environmental economics is substantial (Jaffe, Newell and Stavins, 2005; Stern, 2006; Bennear and Stavins, 2007; Hood, 2011; Rogge and Reichardt, 2016; Kivimaa and Kern, 2016; Waisman, de Coninck and Rogelj, 2019; van den Bergh et al., 2021).[1] Drawing on such insights, many economists who work on climate change – including those who advocate for emissions pricing – conclude that emissions pricing *alone* is inadequate to drive a low-emissions transition. For example, a key textbook on the subject, *The Economics and Politics of Climate Change*, remarks that

> a carbon price would be sufficient to internalize the greenhouse externality in a world without any imperfections. *But, in our imperfect world, a carbon price alone is inadequate*, given the urgency of reducing emissions, the inertia in decision-making, and the other market imperfections, including those relating to low-carbon R&D. So *a carbon price is a necessary, but not a sufficient, component* [of global climate policy]. (Hepburn and Stern, 2009, p.4, emphasis added)

More recently, an expert workshop in the United States concluded that 'carbon pricing cannot stand alone. Politically feasible carbon pricing policies are not sufficient to drive emissions reductions or innovation at the scale and pace necessary' (Jenkins, Stokes and Wagner, 2020).

Some argue that emissions pricing is at best a marginal factor in behaviour change, at worst a distraction (Patt and Lilliestam, 2018; Rosenbloom et al., 2020). But even those who defend emissions pricing will often accept that emissions pricing should be part of a diverse policy portfolio. For example, Kirchner, Schmidt and Wehrle (2019) defend

> what we believe has been the consensus for many years now, namely that the deep decarbonization of our economies essentially requires a comprehensive and disruptive policy package that includes carbon pricing among other measures, such as technology-specific support schemes.

There are climate economists who endorse a more purist approach to emissions pricing (Nordhaus, 2013; Parry, 2019), but this is far from being a professional consensus.

In short, even if the *efficacy* of emissions pricing is granted, it does not follow that emissions pricing is *sufficient* to meet New Zealand's domestic targets and international commitments, let alone to make a fair contribution to global emissions reductions consistent with thresholds such as 1.5°C or 2°C (see Table

1 for how steep those reductions need to be). As Tvinnereim and Mehling (2018) conclude:

> Empirical studies show that carbon pricing can successfully incentivise incremental emissions reductions. But meeting temperature targets within defined timelines as agreed under the Paris Agreement requires more than incremental improvements: it requires achieving net zero emissions within a few decades.

Can the ETS alone drive the low-emissions transition?

The primary pricing instrument in Aotearoa New Zealand is the New Zealand emissions trading scheme (NZ ETS). Yet, as Leining, Kerr and Bruce-Brand (2020) conclude, 'the NZ ETS has not significantly reduced domestic emissions to date'. The reasons for this inefficacy are well canvassed: in particular, the absence of an effective cap on unit volume, unlimited exposure to units of low integrity through international linking, and various transitional measures, such as one-for-two surrender obligations and a fixed-price option, that diluted the price signal. These limitations were partly unintentional design flaws, partly intentional adjustments to 'moderate' the economic impacts of the NZ ETS after the global financial crisis (Hall, 2021).

Of course, this does not mean that the NZ ETS is not capable of driving technological and behavioural change in the future. Successive governments have introduced changes to ETS settings to improve its efficacy, including the cessation of international linking, introduction of a flexible cap on emissions, the phasing out of various transitional measures, and the institutional commitment of the Climate Change Response (Zero Carbon) Amendment Act 2019. Consequently, the price of New Zealand emission units (NZUs) has risen substantially since its nadir in 2013 at NZ$1.45 per tonne to over $60 per tonne. The New Zealand government has also updated its price control settings to mandate an upward trajectory: the price corridor will increase to $30–70 in 2022, and to about $40–110 in 2026 (Ministry for the Environment, 2021c). The upward bounds of these settings would see the NZ ETS trending just below current EU ETS prices, which were 62 euros (NZD$105) per tonne in September 2021.

Table 2. Barriers to the low-emissions transition.

Barrier	Description
1. Imperfect or asymmetric information	Inability to make informed decisions due to lack of accurate and intelligible knowledge about costs and emissions.
2. Uncertainty about future emissions prices	Inability to make informed decisions due to uncertainty about future prices, often as a result of regulatory variation.
3. Split incentives	Instances where the person who pays for an action is not the one who benefits from that action, and therefore lacks the incentive to act. For example, a building owner lacks the incentive to invest in energy efficiency gains that tenants will benefit from.
4. Bounded rationality and myopia	Inability to make informed decisions due to mental heuristics and cognitive biases that distort judgments of economically rational outcomes.
5. Barriers to accessing capital	Inability to access finance to meet the up-front capital costs of emissions reductions.
6. Infrastructure lock-in	Unresponsiveness of systems to changing incentives due to the long life and long lead-in time of fixed infrastructure.
7. Network externalities	Instances where the benefits to an individual from using a product depend on how many others are also using the product. For example, availability of charging infrastructure for EVs may depend upon a critical mass of EV users.
8. Policy coordination or regulatory failure	Inefficiencies and conflicts that result from suboptimal interactions between policies.
9. Co-benefits or other externalities	Public and private value of policies in addition to abatement value, thus favouring a multi-solving policy that addresses overlapping policy challenges. For example, native forest can contribute biodiversity value and landscape resilience in addition to carbon sequestration.
10. Innovation and learning spillovers	The co-benefits of innovation and learning where knowledge from one technology 'spills over' to support further innovation for other technologies.

Consequently, it is reasonable to expect that the NZ ETS will drive greater emissions reductions than it historically has. Its price signal is stronger than ever before. Also, the ETS now has a descending cap on unit volume to be set with regard to emissions budgets. But will associated emissions reductions be substantial enough and certain enough to render other sorts of policy unnecessary?

The Climate Change Commission expects not and recommends instead a 'comprehensive policy package' (Climate Change Commission, 2021, ch.11). Echoing the foundational analysis of 'planetary economics' by Grubb, Hourcade and Neuhoff (2014), emissions pricing is one of three policy pillars, alongside policies to overcome non-price barriers, and to enable innovation and system transformation. The commission argues: 'International research and experience clearly show that the most effective approach … is emissions pricing that works in conjunction with companion policies that help to provide a wider range of low-emissions options' (Climate Change Commission, 2021, p.213). It further identifies 'a range of structural, political and behavioural barriers that prevent people and businesses from making the most of cost-effective opportunities to reduce emissions' (ibid., p,215), which are summarised in Table 2.

This acknowledgement of barriers is not inconsistent with neoclassical economics. Some economists (Bennear and Stavins, 2007; Jenkins, 2014; Stern and Stiglitz, 2021) arrive at this conclusion via the theory of the second best. On this view, emissions pricing might be the 'first-best' response to what Stern (2006) famously described as 'the greatest and widest-ranging market failure ever seen'. However,

Table 3. Type-purpose instrument typology (with instrument examples)

	PRIMARY PURPOSE		
PRIMARY TYPE	Technology push	Demand pull	Systemic
Economic instruments	RD&D* grants and loans, tax incentives, state equity assistance	Subsidies, feed-in tariffs, trading systems, taxes, levies, deposit-refund-systems, public procurement, export credit guarantees	Tax and subsidy reforms, infrastructure provision, cooperative RD&D* grants
Regulation	Patent law, intellectual property rights	Technology/performance standards, prohibition of products/practices, application constraints, planned obsolescence	Market design, grid access guarantee, priority feed-in, environmental/tort liability law
Information	Professional training and qualification, entrepreneurship training, scientific workshops	Training on new technologies, rating and labelling programs, public information campaigns, disclosure and reporting requirements	Education system, thematic meetings, public debates, cooperative RD&D* programs, clusters

Source: Rogge & Reichardt (2016). * RD&D = Research, development and demonstration.

we live in a 'second-best' world which is characterised by multiple constraints on achieving the optimal conditions. The failure to integrate these constraints into integrated assessment models is cause for growing consternation within the climate-modelling community (Fisher-Vanden and Weyant, 2020; Peng et al., 2021). Meanwhile, economic models that incorporate real-world constraints are more attuned to the insufficiency of emissions pricing than is conventional macroeconomic modelling that relies upon first-best assumptions (Stenning, Bui and Pavelka, 2020).

Consequently, there is a role for second-best responses that address market and policy failures, as well as limitations on institutional capacity, prohibitive transaction costs and challenges of political economy. Table 2, adapted from Rogge and Reichardt (2016), identifies a diverse array of economic, regulatory and informational instruments with distinct policy purposes, either to encourage technological innovation and uptake (technology push), to influence consumption (demand pull), or to recalibrate the wider enabling environment (systemic). Note that, on this typology, supply-side measures, such as moratoriums on oil and gas extraction, or the proposed Fossil Fuel Non-proliferation Treaty (Newell and Simms, 2020), fall under the demand pull type.

As Bennear and Stavins (2007) put it, 'Different instruments are appropriate for different types of problems in different circumstances. The challenge is to determine the conditions under which each instrument, or set of instruments, is the appropriate choice.' Interactions among overlapping instruments 'can be detrimental or beneficial' (Fankhauser, Hepburn and Park, 2011), which poses the challenge for policymakers to avoid the former and pursue synergistic policy combinations. We cannot here do justice to the factors that ought to determine choice; suffice to say that economic efficiency is only one of many, which might also include effectiveness, political feasibility, ease of implementation, policy harmonisation, equity or distributional impacts, competitiveness and social acceptability (van den Bergh et al., 2021; Peñasco, Anadón and Verdolini, 2021).

The case of transport: changing systems

To flesh out the argument so far, road transport is an illuminating example. Road transport contributes nearly 43% of New Zealand's energy-related CO_2 emissions, rising by 8% in the three years to 2019 (from 13.6 to 14.7 megatonnes) and projected to rise further (Ministry for the Environment, 2021a). Aotearoa has the highest rate of car ownership in the OECD and the fifth-highest per capita rates of CO_2 emissions from road transport among the 43 OECD countries (OECD, 2017). Light vehicle emissions are 2.65 tonnes CO_2 per person in Aotearoa, compared to 1.3 tonnes in the EU (Buysse and Miller, 2021). Recent modelling by the Ministry of Transport found that, to align with the Climate Change Commission's demonstration pathway of a 41% reduction in transport emissions below 2019 by 2035, there would need to be a 39% reduction in light vehicle distance travelled, a 27% increase in electric vehicle uptake, and increased use of public transport, biofuels and electrification of heavy vehicle like trucks and buses (Ministry of Transport, 2021).

In theory, emissions pricing should incentivise change in transport behaviour. The logic is straightforward: by internalising the costs of climate change into transport decisions, behaviour should shift away from high-emissions transport options towards low-emissions alternatives. Internationally, however, even relatively aggressive pricing has had minor effects on transport emissions. Consider Sweden's carbon tax, the highest in the world and one of the oldest, introduced in 1991 at SEK250 and rising to SEK1,200 (NZ$196) today. Andersson (2019) finds that, in its first 15 years, the carbon tax reduced transport emissions by 6.3%. The scale of impact is disappointing.

Economic modelling of emissions pricing in Aotearoa New Zealand reinforces the point. Hasan (2020) estimates that, to reduce road transport emissions by 44% by 2030, a carbon price of $235/t$CO_2$ is required. An even weaker result comes from recent modelling by the Ministry of Business, Innovation and Employment (2021) which compares a high price pathway that rises from $84/t in 2025 to $250/t in 2050 with a counterfactual reference scenario that assumes a constant $35/t in real terms. The high price pathway only realises a 12–18% reduction in transport sector emissions by 2050, rather than the 84% reduction that is required.

Why such unresponsiveness to high prices? Road transport is an illustrative example of carbon lock-in – that is, 'the interlocking technological, institutional and social forces that can create policy inertia towards the mitigation of global climate change' (Unruh, 2000). Like other developed nations, New Zealand has a car-dependent transport system produced by the over-provision of car infrastructure, inadequate provision of public transport, the facilitation of urban sprawl, mass production in the automotive industry, and the emergence of 'car cultures' which shape human desires and preferences (Mattioli et al., 2020).

It follows that decarbonisation of the transport sector requires substantive socio-technological change. But emissions pricing alone is unlikely to induce such change. Recent reviews (Tvinnereim and Mehling, 2018; Green, 2021; Lilliestam, Patt and Bersalli, 2021) find that, although emissions pricing can induce incremental, short-term operational effects in the energy and transport sectors, such as fuel-switching and energy efficiency, there is thin empirical evidence of technological change, especially as evidenced by zero-carbon investment and innovation. Other analysts argue that the effects are small but not insignificant, and a contingent function of historically low prices (van den Bergh and Savin, 2021). Even so, these analysts concur that deep decarbonisation requires a policy mix.

Consequently, transport researchers are already applying such insights to the design of an integrated policy mix (Axsen, Plötz and Wolinetz, 2020) to address barriers to change. Tellingly, transport is the only sector for which the Climate Change Commission (2021, p.218) proposes fixes for all ten types of market barrier (see Table 2), with a combination of vehicle emissions efficiency standards (to address barriers 1–4 and 10), cost reductions for EVs (2, 4–6), phase-out dates (2, 4), investment in charging infrastructure (6), greater transport alternatives through public and active transport and integrated urban design (6, 8–9), support for low-carbon fuels and mode shifting for heavy transport and freight (6, 10), and adoption of government targets, strategies and shadow pricing (8). Deploying a broad suite of measures to induce technological change is consistent with the transport sector's relative unresponsiveness to emissions pricing.

There are other rationales for going beyond emissions pricing. A virtue of emissions pricing is that, under ideal conditions, it motivates the least-cost emissions reductions. This is the logic of marginal abatement cost (MAC) curves, which are designed to organise abatement options from the most to the least cost-efficient, with the implication that decision makers should start with the former and work progressively towards the latter (e.g., Ministry for the Environment, 2020). As a strategy for decarbonisation, however, MAC curves have numerous weaknesses, one of which is the implication that action ought to be delayed in critical sectors until emissions pricing reaches a certain threshold, only after which expensive sectoral abatement becomes economic. This recommends an abrupt transition that will be needlessly costly, because complex logistical tasks (such as importing EVs and installing charging infrastructure) will be attempted only once the price threshold is reached. This is unrealistic and inefficient: 'In sectors that are particularly expensive and difficult to decarbonise, like transportation, it is therefore preferable to start early to make the transformation as progressive and smooth as possible, minimising long-term costs' (Vogt-Schlib, Meunier and Hallegatte, 2018).

To be clear, this is not a matter of abandoning the efficiency criterion. It is a matter of replacing a static conception of efficiency which is biased towards the present with a dynamic conception of efficiency that stretches across multiple decades. Only on this longer view does the strategic challenge of societal decarbonisation come fully into view. As Patt and Lilliestam (2018) put it, 'Carbon taxes stimulate a search for low-hanging fruit. That ceases to matter when we know we must eventually pick all of the apples on the tree.'

Moreover, if the challenge is technological and structural change, then there is a substantial empirical and theoretical literature on socio-technical transitions which treats the complex problems of lock-in and technological incumbency as central to its analysis (Geels et al., 2017; Loorbach, Frantzeskaki and Avelino, 2017). This literature also has a strong empirical basis by deriving insights from how technological transitions have actually occurred in history (Cantner et al., 2016). On this view, socio-technical transitions are non-linear processes of change that result from interactions between the growth of niche innovations, the weakening of incumbent systems, and increased pressures from the wider social, economic and cultural landscape. Potentially, these processes can be accelerated by the strategic activation of tipping points, where self-reinforcing feedback loops create cascades of technological diffusion, such as rapid EV uptake in Norway and the displacement of coal by renewable energy in the United Kingdom (Lenton, 2020; Sharpe and Lenton, 2021; Farmer et al., 2021). Consequently, transition-oriented approaches place a strong emphasis on proactive strategies to induce change through anticipatory and mission-oriented governance (Tõnurist and Hanson, 2020; Mazzucato, 2021). This places a strong emphasis on the role of research and development and innovation policy, but ultimately involves pragmatic support for whatever changes will destabilise incumbent systems and support the dispersal of alternatives (Geels and Schot, 2007). Emissions pricing is critical as a

Emissions pricing is critical as a system-wide lever … particularly to weaken the market advantage of high-emissions systems and assist the cost-competitiveness of low-emissions alternatives.

system-wide lever (van den Bergh and Botzen, 2020), particularly to weaken the market advantage of high-emissions systems and assist the cost-competitiveness of low-emissions alternatives. But on a systems view, pricing might be the complementary policy, while non-pricing policies such as technological support and regulation are the main act.

Can the ETS alone ensure that the transition is just?

Further reasons for policy mixes relate to the constraints of political economy (Jenkins, 2014; Mildenberger, Lachapelle and Harrison, 2020). Individuals and organisations, rather than respond to a price mechanism by mitigating emissions, may instead attempt to suppress or avoid emissions pricing by exercising political influence. This may occur through political lobbying and petitioning, political party donations, submissions to policy consultations, tactical voting, even protest and civil disobedience. Consequently, emissions pricing produces its own political headwinds which result in its moderation, selective exemptions or even (in the case of Australia's carbon pricing scheme) its own undoing (ibid., ch.6).

On the flipside, emissions pricing might also lack broad-based constituencies of support. Indeed, Meckling and Allan (2017) show that it is precisely complementary policies that help to build actual support for pricing instruments. Green innovation and industrial policy reduce the burden of emission pricing by helping low-emissions technologies to 'travel up the learning curve and down the cost curve' and create new interest groups that see a competitive advantage from emissions pricing.

There is a significant literature on resistance to climate action by companies and individuals who self-interestedly seek to avoid the costs of internalising externalities (Supran and Oreskes, 2017). As a timely example, Exxon Mobil was recently exposed for publicly endorsing emissions pricing in the US on precisely the grounds that it is politically unfeasible and therefore a costless signal for the company (Carter, 2021). It is easy to imagine a parallel argument in Aotearoa New Zealand; that is, to endorse a sole reliance on the ETS, knowing that elected officials could never tolerate the political consequences of raising prices to a level sufficient to meet emissions budgets and New Zealand's NDC (nationally determined contribution).

But emissions pricing faces resistance not only for self-interested reasons, but also for reasons of justice. Equity is an essential aspect of a just transition (Hall, 2019; White and Leining, 2021). Insofar as emissions pricing creates inequitable burdens, it therefore results in unjust transitions that lack political legitimacy and so are likely to be constrained by the negative feedbacks of political economy. The yellow jacket protests in France (*les gilets jaunes*) is a striking example, but not the only one (Green, 2021).

One issue is the different sectoral effects of a single price. Recent experience suggests that, in contrast to the transport sector, land use change is highly responsive to emissions pricing. Ministry for the Environment modelling suggested that the area of farmland economic to convert to forest as a function of marginal abatement cost is 4.7 million hectares at $50/t. At over $100/t, forestry conversions are economic across almost the entire 7.1 million hectares available for planting, which effectively displaces the entire sheep and beef sector, as well as dairy land. Although the speed of actual forestry conversions would be inhibited by various logistical bottlenecks (such as availability of land, labour and nursery supplies), investment behaviour is already starting to reflect these incentives. However, a reliance on large-scale, ETS-driven afforestation is highly questionable from the perspective of climate adaptation, given the strong incentives for exotic monocultures (Anderegg et al., 2020;

Puncturing the waterbed

One argument against overlapping policies within the context of the NZ ETS is that, even if additional policies succeed in reducing emissions, this merely frees up units for other emitters to use. This is the so-called 'waterbed effect', an analogy with the fixed volume of water in a waterbed, which, if squeezed in one place, bulges out elsewhere. Subsequently, it is argued that 'the ETS entirely neutralises other emissions policies' (Burgess, 2021).

However, under current conditions, where there is strong demand for units to bank in private accounts, it is far from certain that units freed up by abatement will be used by others in the short-term (Sandbag, 2016). Emitters are motivated by many factors beyond emissions pricing, and unit holders are motivated to sell at a higher future price. Consequently, many units will likely join the stockpile, already at 138 million units.

But does this not simply mean that the waterbed effect will occur across time, as stockpiled units trickle back into secondary markets in future? Not necessarily, because this can be managed by harmonising emissions budgets, ETS unit supply settings and emissions reduction plan measures as an integrated package. Policy design can 'puncture the waterbed' (Perino, 2018) so that, over the long run, abating one tonne of emissions results in an emission reduction of less than one tonne and more than zero.

In short, the waterbed effect is not an inevitability, it is a policy choice.[2]

Messier et al., 2021). There is also a lost opportunity to achieve more integrated outcomes that weave carbon into the landscape and maximise co-benefits such as biodiversity gains and disaster risk reduction (Hall, 2018). Finally, carbon-only forests lack social licence among rural communities (Collins and McFetridge, 2021), not least because regional economic activity is limited and long-term liabilities are potentially significant (Rau, 2021). Consequently, large-scale afforestation poses challenges for regional equity (Frame, 2019) because rural economies are disproportionately exposed to the risks, whereas urban economies accrue many benefits by selling and purchasing offsets to deter decarbonisation in transport, energy and industry (McLaren, 2020).

Another equity issue is the regressive effect of emissions pricing on low-income households, who spend a higher proportion of their discretionary income on consumables. The regressiveness of this inflationary pressure is not inevitable (Sager, 2019), but it is more likely in developed countries with high economic inequality (Andersson and Giles, 2020), such as Aotearoa New Zealand. Indeed, a 2019 Treasury analysis found that the impact of emissions pricing on lowest income quintile households was twice that on the highest income quintile households. This is because emissions-intensive goods constitute a higher proportion of household spending for low-income households, and because '[w]ith fewer resources, lower income households will have lower ability to change behaviour or invest to reduce their exposure to emissions prices' (Ministry for the Environment, 2019, p.66). Māori are disproportionately exposed to this regressive impact, which demonstrates how the Crown can fail to uphold its partnership obligations to Māori by neglecting how climate change policy can reinforce and amplify historical and demographic inequities (Bargh, 2019).

A fix for inequity?

Distributional issues can be managed and ameliorated by integrated policymaking, such as labour market policies, public education and training, social assistance programmes, regional economic development, wider tax settings, and targeted financial and technical support with technology change.

It can also be managed through instrument design, in particular the targeted use of revenue raised by emissions pricing. Notably, the government recently announced that it will hypothecate revenue from the auctioning of NZUs towards the low-emissions transition. Over 2021–25, auctioning 89.6 million units with an estimated average price of $35/t would generate $3.1 billion in revenue (Ministry for the Environment, 2021b), but at the current price of $65/t that implies a total revenue of $5.8 billion. International survey evidence shows that people are more amenable to emissions pricing if the revenue is recycled (Baranzini and Carattini, 2017) – either diverted into climate mitigation and adaptation projects, or redistributed as a payment to households, often known as a climate dividend (Klenert et al., 2018). Evenly split among New Zealand's population, this latter option would create an annual dividend of about $125–233 per person (assuming a price range of $35–65/t).

If the only thing at stake were inequity, a climate dividend might provide a substantive solution. Yet empirical research on these redistributive mechanisms is rather less conclusive. Indeed, analysis of existing climate dividends in Canada and Switzerland reveals that public support for dividends is ambivalent, with people's attitudes shaped more by political orientation than the dividend itself (Mildenberger, Lachapelle and Harrison, 2020).

First, there is a strong cognitive element. A recent survey of French households tested a climate dividend proposal, yet found only 10% in favour and 70% in opposition, because most households wrongly believed that this progressive scheme would not benefit them (Douenne and Fabre, forthcoming). Of course, mere disapproval should not be decisive against implementing a policy, especially when disapproval rests on false beliefs. However, if the primary purpose of the carbon dividend is to enhance the political legitimacy of emissions pricing, then it is not obvious that a carbon dividend alone will succeed (at least not without a complementary communications strategy to overcome the barrier of bounded rationality). Moreover, if enhancing legitimacy is the objective, then it is notable that using revenue for climate-aligned investments is generally preferred over climate dividends by survey respondents overseas (Baranzini and Carattini, 2017; Douenne and Fabre, 2020).

> In short, the NZ ETS is symptomatic of 'the poverty of theory' that dominates contemporary policymaking, which treats 'policy instruments as widgets', as tools to be applied to definite problems with predictable effects.

Second, if the purpose of the exercise is decarbonisation, then why not reduce the systemic barriers to the low-emissions transition, rather than merely moderate the maldistribution of emissions pricing? If the problem is a car-dependent transport system, then individual annual dividends of $125–233 cannot help that much. These could contribute to the price of an e-bike or EV, or bus and train fares, but cannot overcome the lock-in factors that favour private vehicles, such as urban sprawl, car-centric infrastructure, inadequate public transport, and so on. What might instead make the difference is public investment in public infrastructure, such as cycleways or public transport options, in order to induce a socio-technical transition. This is the approach taken in the EU, Quebec and California, which redirect ETS auctioning revenue to sectors such as transport, renewable energy, energy efficiency, research and development and adaptation (Santikarn et al., 2019). Without substantial investment, without the expansion of choice that a multi-modal transport system allows, households will remain exposed to the emissions price, and so transport-related costs will increase as a proportion of household spending. In Aotearoa New Zealand, transport already accounts for a significant proportion (16%) of household spending, just behind food (17%) and housing (26%) (Statistics New Zealand, 2019).

The issue of price elasticity is critical here. Price elasticity is a measure of a market's response to price changes. If a market is elastic with respect to emissions pricing, then people are responsive to the higher costs of emissions-intensive goods and services – for example, by switching to low-emissions alternatives or reducing consumption. However, elasticity in transport is a function not only of emissions pricing, but also of other price factors, availability of alternative transport options, demographic factors, land use and urban form, and demand management strategies (for review, see Litman, 2021). It is telling that the *gilets jaunes* protests first manifested in peri-urban and rural France,

> where there is no practical alternative to the personal car as a mode of transport, and where rent or the price of housing closer to work are not within the reach of many on a modest budget, [so] the sacrifices must involve other areas of life, such as food, clothing, or the ability to go on holiday. (Devellennes, 2021, p.84)

For low-income households, inelasticity entails regrettable trade-offs in household spending; meanwhile, high-income households might also be inelastic to price because they can afford to bear the additional carbon costs. As long as private vehicles remain a necessity, increased emissions pricing can intensify economic inequalities without overcoming the causes of price inelasticity.

Emissions pricing is clearly insufficient as a sole response to climate change mitigation, particularly at this current juncture where deep, drastic reductions in greenhouse gas emissions are required.

A lack of recognition

The example of *les gilets jaunes* speaks to one final issue: the shortcomings of the governance regimes that often uphold emissions pricing. Resistance to France's fuel tax was not only a protest against the economic injustice of emissions pricing, but also, 'for many, a desperate plea to be seen and be heard, to be recognized as human beings with legitimate interests and needs' (ibid.). In other words, the injustice of the fuel tax related not only to equity, but also inclusivity; not only the politics of redistribution, but also the politics of recognition – that is, the human need to have one's experience acknowledged, validated and treated with equal respect.

The NZ ETS was not designed or implemented with such matters in mind (Driver, Parsons and Fisher, 2018). Furthermore, the NZ ETS's complexity confounds not only the public and their political representatives, but even the journalists who might simplify and explain its mechanics (Mitchell, 2020). This is not an instrument that easily permits a sense of understanding or participation among citizens.

Again, this is not a sufficient reason to dispense with the NZ ETS, but it is reason to be clear-eyed about its political frailties. If prices rise and contribute noticeably to living costs or other unjust impacts, the NZ ETS cannot assume strong loyalty and buy-in from the public, even among those who support climate action. Although it is designed to preserve free choice as a market instrument, its imposition of a price may still be perceived as a form of domination by those it most affects. This speaks to its practical value of creating an incentive – that is, an extrinsic motivation – to change the behaviour of economic agents who otherwise lack the interest to act on climate change. However, there is an associated risk of thereby crowding out people's intrinsic motives to act (Rode, Gómez-Baggethun and Krause, 2015), such as the common human desire to enhance prosperity for one's children and for future generations.

In short, the NZ ETS is symptomatic of 'the poverty of theory' that dominates contemporary policymaking, which treats 'policy instruments as widgets', as tools to be applied to definite problems with predictable effects. Actually these instruments are 'made and remade in specific contexts … mutate as they travel … [and] are never divorced from politics' (Boyd, 2021, p.472). Refocusing our attention on the politics of climate change – not merely as a source of inconvenience, hindrance and irrationality, but also creativity, local intelligence and sovereign power – might help us to meet the scale, complexity and urgency of the climate challenge.

Conclusion

Emissions pricing is clearly insufficient as a sole response to climate change mitigation, particularly *at this current juncture where deep*, drastic reductions in greenhouse gas emissions are required. The NZ ETS can play an important role in encouraging efficiencies and operational change by creating a price, and also exercises a limit on cumulative emissions by managing volume. But deep decarbonisation and technological change will require transition-oriented policies that are committed to transforming systems in ways that ensure just outcomes and secure broad, enduring public support.

In Donella Meadows' classic analysis of leverage points – that is, 'places in the system where a small change could lead to a large shift in behaviour' (Meadows, 2008, p.145) – she acknowledges the power of pricing externalities, of '[s]trengthening and clarifying market signals, such as full-cost accounting' (ibid., p.154). Critically, though, there are other leverage points she regards as more important, as more capable of inducing systems change. She talks about reinforcing feedback loops which induce growth and collapse, information flows that help a system to understand itself, rules and the power to impose them, and the capacity of complex systems to self-organise and adapt. Above all, however, she talks of goals and paradigms. Reset the purpose or function of systems, or transcend the mindset out of which the system arose, and transformative change is possible.

It is perhaps no coincidence that an absolutist stance on emissions pricing – despite all the evidence in favour of policy mixes – has intensified at the same time that the paradigm of neoclassical economics is losing its pre-eminence in environmental economics and policy (Galbraith, 2020). As discourse analysis (Meckling and Allan, 2020) shows, in the early to mid-2000s the prevalence of neoclassical economics gave way to greater policy diversity, especially through the mainstreaming of post-Keynesian and neo-Schumpeterian accounts of the green economy. After the global financial crisis, these latter paradigms retained their influence while market-based policy lost ground. This paradigm shift underpins the reframing of the climate challenge from 'a zero-sum to a win–win logic' (ibid.), which treats climate action as an economic opportunity for green innovation and industrial policy rather than merely a cost. The demotion of emissions pricing from the status of panacea to just one element in the policy mix is a sub-theme in this larger story. And this paradigm shift is potentially the leverage point that will make the greatest difference.

1 Further references are available in a longer version of this article, available at planetaryecology.org.

2 See further discussion of the waterbed effect in the longer version of this article at planetaryecology.org.

References

Aldy, J. and R. Stavins (2012) 'The promise and problems of pricing carbon: theory and experience', *Journal of Environmental Development*, 21, pp.152–80

Anderegg, W.R.L. et al. (2020) 'Climate-driven risks to the climate mitigation potential of forests', *Science*, 368 (5497)

Andersson, J. (2019) 'Carbon taxes and CO2 emissions: Sweden as a case study', *American Economic Journal: Economic Policy*, 11 (4), pp.1–30

Andersson, J. and A. Giles (2020) *The Distributional Effects of a Carbon Tax: the role of income inequality*, working paper 349, London: Grantham Research Institute on Climate Change and the Environment, London School of Economics

Axsen, J., P. Plötz and M. Wolinetz (2020) 'Crafting strong, integrated policy mixes for deep CO2 mitigation in road transport,' *Nature Climate Change*, 10, pp.809–18

Baranzini, A., S.J. van den Bergh, S. Carattini, R.B. Howarth, E. Padilla and J. Roca (2017) 'Carbon pricing in climate policy: seven reasons, complementary instruments, and political economy considerations', *Wiley Interdisciplinary Reviews: Climate Change*, 8 (4), e462

Baranzini, A. and S. Carattini (2017) 'Effectiveness, earmarking and labeling: testing the acceptability of carbon taxes with survey data', *Environmental Economics and Policy Studies*, 19, pp.197–227

Bargh, M. (2019) 'A tika transition', in D. Hall (ed.), *A Careful Revolution: towards a low-emissions future*, Wellington: Bridget Williams Books

Bayer, P. and M. Aklin (2020) 'The European Union emissions trading system reduced CO2 emissions despite low prices', *PNAS*, 117 (16), pp.8804–12

Bennear, L. and R. Stavins (2007) 'Second-best theory and the use of multiple policy instruments', *Environmental and Resource Economics*, 37 (1), pp.111–29

Best, R., P.J. Burke and F. Jotzo (2020) 'Carbon pricing efficacy: cross-country evidence', *Environmental and Resource Economics*, 77, pp.69–94

Boyd, W. (2021) 'The poverty of theory: public problems, instrument choice, and the climate emergency', *Columbia Journal of Environmental Law*, 46 (2), pp.399–487

Burgess, M. (2021) *Emissions Trading Scheme FAQ*, Wellington: New Zealand Initiative

Burke, J., R. Byrnes and S. Fankhauser (2019) *How to Price Carbon to Reach Net-zero Emissions in the UK*, London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science

Buysse, C. and J. Miller (2021) 'Transport could burn up the EU's entire carbon budget', ICCT, https://theicct.org/blog/staff/eu-carbon-budget-apr2021

Cantner, U., H. Graf, J. Herrmann and M. Kalthaus (2016) 'Inventor networks in renewable energies: the influence of the policy mix in Germany', *Research Policy*, 45 (6), pp.1165–84

Carter, L. (2021) 'Inside Exxon's playbook: how America's biggest oil company continues to oppose action on climate change', *Unearthed*, 30 June, https://unearthed.greenpeace.org/2021/06/30/exxon-climate-change-undercover/

Climate Change Commission (2021) *Ināia Tonu Nei: a low emissions future for Aotearoa: advice to the New Zealand government on its first three emissions budgets and direction for its emissions reduction plan 2022–2025*, Wellington: He Pou a Rangi Climate Change Commission

Climate Leadership Council (2019) 'Economists' statement on carbon dividends', *Wall Street Journal*, 16 January, https://www.wsj.com/articles/economists-statement-on-carbon-dividends-11547682910

Collins, H. and A. McFetridge (2021) *The Impacts of Afforestation on Rural Communities: a case study in the Tararua district of New Zealand*, report prepared for Tararua District Council

Concept (2017) *Cost-effective Energy Options for Transitioning New Zealand to a Low-carbon Economy*, Wellington: Concept Consulting Group Ltd

Devellennes, C. (2021) *The Gilets Jaunes and the New Social Contract*, Bristol: Bristol University Press

Douenne, T. and A. Fabre (2020) 'French attitudes on climate change, carbon taxation and other climate policies', *Ecological Economics*, 169, 106496

Douenne, T. and A. Fabre (forthcoming) 'Yellow vests, pessimistic beliefs, and carbon tax aversion', *American Economic Journal: Economic Policy*

Driver, E., M. Parsons and K. Fisher (2018) 'Technically political: the post-politics(?) of the New Zealand Emissions Trading Scheme', *Geoforum*, 97, pp.253–67

Environmental Protection Authority (2021) 'Privately held units', https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/market-information/privately-held-units/

Fankhauser, S., C. Hepburn and J. Park (2010) 'Combining multiple climate policy instruments: how not to do it', *Climate Change Economics*, 1 (3), pp.209–25

Farmer, J., C. Hepburn, M.C. Ives, T. Hale, T. Wetzer, P. Mealy, R. Rafaty, S. Srivastav and R. Way (2021) 'Sensitive intervention points in the post-carbon transition', *Science*, 364 (6436), pp.132–4

Fisher-Vanden, K. and J. Weyant (2020) 'The evolution of integrated assessment: developing the next generation of use-inspired integrated assessment tools', *Annual Review of Resource Economics*, 12 (1), pp.471–87

Frame, D. (2019) 'Bringing the people with you', in D. Hall (ed.), *A Careful Revolution: towards a low-emissions future*, Wellington: Bridget Williams Books

Galbraith, J. (2020) 'Economics and the climate catastrophe', *Globalizations*, 18 (7), pp.1117–22

Geels, F. and J. Schot (2007) 'Typology of sociotechnical transition pathways', *Research Policy*, 36 (3), pp.399–417

Geels, F., B. Sovacool, T. Schwanen and S. Sorrell (2017) 'The socio-technical dynamics of low-carbon transitions', *Joule*, 1 (3), pp.463–79

Green, J. (2021) 'Does carbon pricing reduce emissions? A review of ex-post analyses', *Environmental Research Letters*, 16, 043004

Grubb, M., J.-C. Hourcade and K. Neuhoff (2014) *Planetary Economics: energy, climate change and the three domains of sustainable development*, London: Routledge

Haites, E., D. Maosheng, K. Gallagher, S. Mascher, E. Narassimhan, K. Richards and M. Wakabayashi (2018) 'Experience with carbon taxes and greenhouse gas emissions trading systems', *Duke Environmental Law and Policy Forum*, 29, pp.109–82

Hall, D. (2018) *The Interwoven World | Te Ao i Whiria: toward an integrated landscape approach in Aotearoa New Zealand*, discussion paper, Auckland: The Policy Observatory

Hall, D. (ed.) (2019) *A Careful Revolution: towards a low-emissions future*, Wellington: Bridget Williams Books

Hall, D. (2021) 'Rhetoric and reality in New Zealand's climate leadership: "My generation's nuclear-free moment"', in R. Wurzel, M. Skou Andersen and P. Tobin (eds), *Climate Governance across the Globe: pioneers, leaders and followers*, London: Routledge

Hartwich, O. (2021) 'The problem with Climate Commission chair Rod Carr's economic argument', *New Zealand Herald*, 8 June

Hasan, M. (2020) 'Understanding the costs, benefits, mitigation potentials and ethical aspects of New Zealand's transport emissions reduction policies', PhD thesis, Victoria University of Wellington

Hazeldine, T. (2021) 'The Climate Change Commission is way off course', *New Zealand Herald*, 9 July

Hepburn, C. (2006) 'Regulating by prices, quantities or both: an update and an overview', *Oxford Review of Economic Policy*, 22 (2), pp.226–47

Hepburn, C. and N. Stern (2009) 'The global deal on climate change', in D. Helm and C. Hepburn (eds), *The Economics and Politics of Climate Change*, Oxford: Oxford University Press

Hood, C. (2011) *Summing Up the Parts: combining policy instruments for least-cost mitigation strategies*, Paris: OECD/International Energy Agency

Howard, P. and D. Sylvan (2015) *Expert Consensus on the Economics of Climate Change*, New York: Institute for Policy Integrity

Jaffe, A., R. Newell and R. Stavins (2005) 'A tale of two market failures: technology and environmental policy', *Ecological Economics*, 54 (2–3), pp.164–74

Jenkins, J. (2014) 'Political economy constraints on carbon pricing policies: what are the implications for economic efficiency, environmental efficacy, and climate policy design?', *Energy Policy*, 69, pp.467–77

Jenkins, J., L. Stokes and G. Wagner (eds) (2020) 'Carbon pricing and innovation in a world of political constraints', workshop report

Kirchner, M., J. Schmidt and S. Wehrle (2019) 'Exploiting synergy of carbon pricing and other policy instruments for deep decarbonization', *Joule*, 3 (4), pp.891–3

Kivimaa, P. and F. Kern (2016) 'Creative destruction or mere niche support? Innovation policy mixes for sustainability transitions', *Research Policy*, 45, pp.205–217

Klenert, D. et al. (2018) 'Making carbon pricing work for citizens', *Nature Climate Change*, 8, pp.669–77

Leining, C., S. Kerr and B. Bruce-Brand (2020) 'The New Zealand Emissions Trading Scheme: critical review and outlook for three design innovations', *Climate Policy*, 20 (2), pp.246–64

Lenton, T. (2020) 'Tipping positive change', *Philosophical Transactions of the Royal Society B: Biological Sciences*, 375 (1794), 20190123

Lilliestam, J., A. Patt and G. Bersalli (2020) 'The effect of carbon pricing on technological change for full energy decarbonization: a review of empirical ex-post evidence', *WIREs Climate Change*, 12 (1), e681

Lin, B. and X. Li (2011) 'The effect of carbon tax on per capita CO2 emissions', *Energy Policy*, 39 (9), pp.5137–46

Litman, T. (2021) *Understanding Transport Demands and Elasticities: how prices and other factors affect travel behavior*, Victoria Transport Policy Institute

Loorbach D., N. Frantzeskaki and F. Avelino (2017) 'Sustainability transitions research: transforming science and practice for societal change', *Annual Review of Environment and Resources*, 42, pp.599–626

Mattioli, G., C. Roberts, J.K. Steinberger and A. Brown (2020) 'The political economy of car dependence: a systems of provision approach', *Energy Research and Social Science*, 66, 101486

Mazzucato, M. (2021) *Mission Economy: a moonshot guide to changing capitalism*, London: Allen Lane

McLachlan, R. (2021) 'Lawyers challenge New Zealand's proposed emissions budgets as inconsistent with the 1.5 goal', *The Conversation*, 7 July, https://theconversation.com/lawyers-challenge-new-zealands-proposed-emissions-budgets-as-inconsistent-with-the-1-5-goal-162504

McLaren, D. (2020) 'Quantifying the potential scale of mitigation deterrence from greenhouse gas removal techniques', *Climatic Change*, 162, pp.6411–28

Meadows, D. (2008) *Thinking in Systems: a primer*, White River Junction: Chelsea Green Publishing

Meckling, J. and B. Allan (2020) 'The evolution of ideas in global climate policy', *Nature Climate Change*, 10, pp.434–8

Messier, C. et al. (2021) 'For the sake of resilience and multifunctionality, let's diversify planted forests!', *Conservation Letters*, e12829

Mildenberger, M. (2020) *Carbon Captured: how business and labour control climate politics*, Cambridge, Mass: MIT Press

Mildenberger, M., E. Lachapelle and K. Harrison (2020) 'Climate rebates did not substantially increase support for Canadian carbon pricing', working paper

Ministry for the Environment (2019) *Reforming the New Zealand Emissions Trading Scheme: proposed settings – consultation document*, Wellington: Ministry for the Environment

Ministry for the Environment (2020) *Marginal Abatement Cost Curves Analysis for New Zealand: potential greenhouse gas mitigation options and their costs*, Wellington: Ministry for the Environment
Ministry for the Environment (2021a) *New Zealand's Greenhouse Gas Inventory, 1990–2019*, Wellington: Ministry for the Environment
Ministry for the Environment (2021b) *Proposed Changes to NZ ETS and SGG Levy Regulations 2021: consultation document*, Wellington: Ministry for the Environment
Ministry for the Environment (2021c) 'Release of updates to NZ ETS regulations and SGG levy', Wellington: Ministry for the Environment
Ministry of Business, Innovation and Employment (2021) *Energy in New Zealand 2021*, Wellington: Ministry of Business, Innovation and Employment
Ministry of Transport (2021) *Hīkina te Kohupara: kia mauri ora ai te iwi / Transport Emissions: pathways to net zero by 2050*, Wellington: Ministry of Transport
Mitchell, C. (2020) 'Confused? Why not understanding the Emissions Trading Scheme is the point', *Stuff*, 21 February, https://www.stuff.co.nz/environment/climate-news/119665441/if-youre-confused-you-understand-why-not-understanding-the-emissions-trading-scheme-is-the-point
Narassimhan, E., K. Gallagher, S. Koester and J.R. Alejo (2018) 'Carbon pricing in practice: a review of existing emissions trading systems', *Climate Policy*, 18 (8), pp.967–91
Newell, P. and A. Simms (2020) 'Towards a fossil fuel non-proliferation treaty', *Climate Policy*, 20 (8), pp.1043–54
Nordhaus, W. (2013) *The Climate Casino: risk, uncertainty, and economics for a warming world*, New Haven: Yale University Press
OECD (2017) *Environmental Pressures Rising in New Zealand*, Paris: OECD
Parry, I. (2019) 'Putting a price on pollution: carbon-pricing strategies could hold the key to meeting the world's climate stabilization goals', International Monetary Fund, https://isni.org/isni/0000000404811396
Patt, A. and J. Lilliestam (2018) 'The case against carbon prices', *Joule*, 2 (12), pp.2494–8
Peñasco, C., L. Anadón and E. Verdolini (2021) 'Systematic review of the outcomes and trade-offs of ten types of decarbonization policy instruments', *Nature Climate Change*, 11, pp.257–65
Peng, W., G. Iyer, G. Bosetti, V. Chaturvedi, J. Edmonds, A. Fawcett, S. Hallegatte, D. Victor, D. van Vuuren and J. Weyant (2021) 'Climate policy models need to get real about people: here's how', *Nature*, 594, pp.174–6
Perino, G. (2018) 'New EU ETS phase 4 rules temporarily puncture waterbed', *Nature Climate Change*, 8, pp.262–4
Prebble, R. (2021) 'New climate report is just socialist quackery', *New Zealand Herald*, 16 June
Rafaty, R., G. Dolphin and F. Pretis (2020) *Carbon Pricing and the Elasticity of CO_2* Emissions, working paper in economics 20116, Cambridge: Faculty of Economics, University of Cambridge
Rau, C. (2021) *Report on the Impacts of Permanent Carbon Farming in Te Tairāwhiti Region*, Gisborne: BDO and Trust Tairāwhiti
Rode, J., E. Gómez-Baggethun and T. Krause (2015) 'Motivation crowding by economic incentives in conservation policy: a review of the empirical evidence', *Ecological Economics*, 117, pp. 270–82
Rogge, K.S. and K. Reichardt (2016) 'Policy mixes for sustainability transitions: an extended concept and framework for analysis', *Research Policy*, 45, pp.1620–35
Rosenbloom, D., J. Markard, F. Geels and L. Fuenfschilling (2020) 'Opinion: why carbon pricing is not sufficient to mitigate climate change – and how "sustainability transition policy" can help', *Proceedings of the National Academy of Sciences*, 117 (16), pp.8664–8
Sager, L. (2019) *The Global Consumer Incidence of Carbon Pricing: evidence from trade*, working paper 320, London: Grantham Research Institute on Climate Change and the Environment
Sandbag (2016) *Puncturing the Waterbed Myth*, https://sandbag.be/wp-content/uploads/2016/12/Waterbed_report_A.pdf
Santikarn, M., C. Kardish, J. Ackva and C. Haug (2019) *The Use of Auction Revenue from Emissions Trading Systems: delivering environmental, economic, and social benefits*, Berlin: ICAP
Sharpe, S. and T. Lenton (2021) 'Upward-scaling tipping cascades to meet climate goals: plausible grounds for hope', *Climate Policy*, 21 (4), pp.421–33
Sorrell, S. and J. Sijm (2003) 'Carbon trading in the policy mix', *Oxford Review of Economic Policy*, 19 (3), pp.420–37
Statistics New Zealand (2019) 'Household expenditure statistics: year ended June 2019', https://www.stats.govt.nz/information-releases/household-expenditure-statistics-year-ended-june-2019
Stenning, J., H. Bui and A. Pavelka (2020) *Decarbonising European Transport and Heating Fuels: is the EU ETS the right tool?*, Cambridge: Cambridge Econometrics
Stern, N. (2006) *Stern Review Report on the Economics of Climate Change*, London: Treasury
Stern, N. and J. Stiglitz (2021) *The Social Cost of Carbon, Risk, Distribution, Market Failures: an alternative approach*, working paper 28472, Cambridge, Mass: National Bureau of Economic Research, http://www.nber.org/papers/w28472
Supran, G. and N. Oreskes (2017) 'Assessing ExxonMobil's climate change communications (1977–2014)', *Environmental Research Letters*, 12, 084019
Tõnurist, P. and A. Hanson (2020) *Anticipatory Innovation Governance: shaping the future through proactive policy making*, working papers on public governance, 44, Paris: OECD Publishing
Tvinnereim, E. and M. Mehling (2018) 'Carbon pricing and deep decarbonisation', *Energy Policy*, 121, pp.185–9
Unruh, G. (2000) 'Understanding carbon lock-in', *Energy Policy*, 28 (12), pp.817–30
van den Bergh, J. and W. Botzen (2020) 'Low-carbon transition is improbable without carbon pricing', *PNAS*, 117 (38), pp.23219–20
van den Bergh, J. and I. Savin (2021) 'Impact of carbon pricing on low-carbon innovation and deep decarbonisation: controversies and path forward', *Environmental and Resource Economics*, 9
van den Bergh, J., J. Castro, S. Drews, F. Exadaktylos, J. Foramitti, F. Klein, T. Konc and I. Savin (2021) 'Designing an effective climate-policy mix: accounting for instrument synergy', *Climate Policy*, 21 (6), pp.745–64
Vogt-Schilb, A., G. Meunier and S. Hallegatte (2018) 'When starting with the most expensive option makes sense', *VoxEU*, 29 March, https://voxeu.org/article/climate-policy-when-starting-most-expensive-option-makes-sense
Waisman, H., H. de Coninck and J. Rogelj (2019) 'Key technological enablers for ambitious climate goals: insights from the IPCC special report on global warming of 1.5°C', *Environmental Research Letters*, 14 (11), 111001
White, D. and C. Leining (2021) 'Developing a policy framework with indicators for a "just transition" in Aotearoa New Zealand', *Policy Quarterly*, 17 (3), pp.3–12
World Bank (2020) *State and Trends of Carbon Pricing 2020*, Washington, DC: World Bank