Countervailing forces

Climate targets and implications for competitiveness, leakage and innovation

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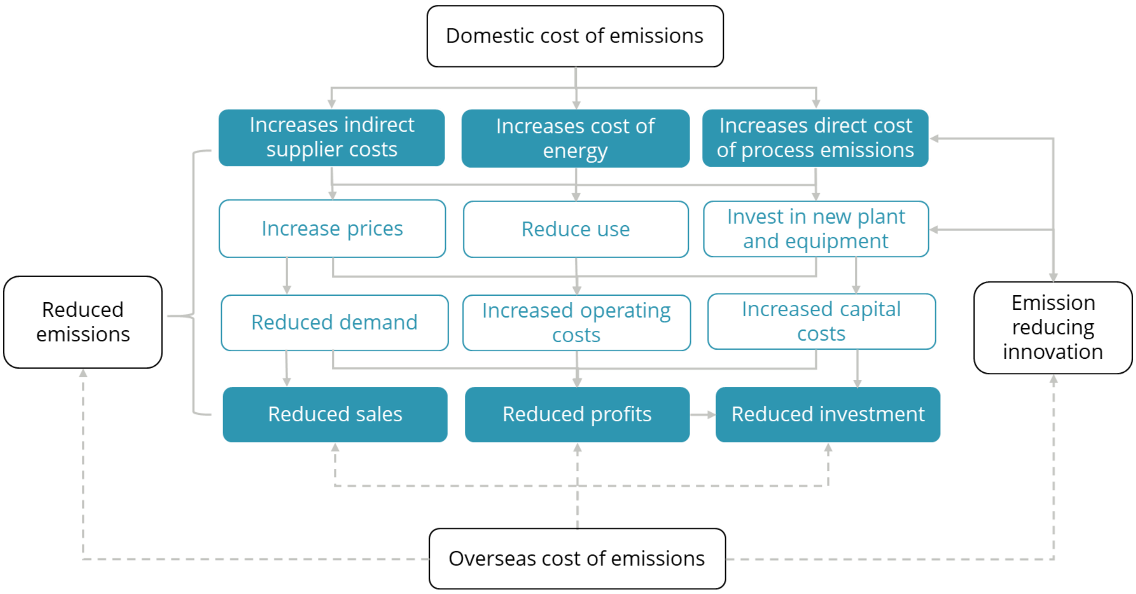
Summary

Climate policy frequently raises concerns about comparability, equity and effectiveness. Who should do what, when and how much.

Part and parcel of these concerns is the worry that companies will be at a competitive disadvantage if domestic policy moves faster or further than in other countries. Firms can respond to costs imposed on emissions – by increasing prices, reducing use of emissions intensive inputs, or investing in low emission plant and machinery – but the general direction of effect will be towards reductions in sales, profitability and potentially investment (as in Figure 1 below). These are generally cast as problems of 'competitiveness'.

This report details actual and potential differences in climate policies and related costs in New Zealand and in competitor and customer markets for New Zealand exporters and importers. The analysis suggests New Zealand firms have faced effective costs of emissions that are not very high by international standards but have been high compared with those of our major trading partners in the Asia Pacific region.

FIGURE 1: EMISSIONS COSTS AND FIRM RESPONSES



That said, on all main indicators of competitiveness effects (profits, output, employment, and trade) there is no perceptible evidence of negative effects of existing climate policy on emissions intensive and trade exposed industries. This is most likely because New Zealand's main climate policy instrument – the Emissions Trading Scheme (ETS) – has imposed modest costs on emissions thus far.

It is likely that this will change in future – that emissions intensive and trade exposed industries firms will face declining competitiveness. This conclusion is based on an expectation that climate policies will continue to be applied unevenly around the world and especially in

Asia Pacific. This unevenness is embedded in socio-economic differences between countries and in the Paris Agreement on climate change.

A global patchwork of climate policies means that there is a high likelihood of a significant widening of cost differentials between New Zealand producers and their overseas competitors. Although only a handful of emissions intensive industries will be troubled by this.

The prospect of significant differences in costs then raises questions about the capacity of New Zealand firms to innovate and obtain offsetting sources of competitive advantage. Overseas evidence provides qualified support for significant adjustment and potential for positive impacts through increased innovation and even productivity improvements.

To gain some insight into the ability of New Zealand firms to innovate and compete in a world of uneven carbon prices, this report examines data and analyses on trends in innovation and productivity growth. It concludes that historically weak innovation and comparatively poor productivity growth are reasons to doubt whether innovation and adaptation by New Zealand firms will be sufficient to overcome potentially wide cost differentials.

This also raises the possibility of leakage, where economic activity migrates and mitigation of emissions in New Zealand is offset by an increase elsewhere. If this happens, global emissions may not fall at all and may even increase.

For leakage to occur, production in New Zealand would have to be displaced by production that is more emissions intensive. In energy-intensive industries, overseas production does tend to be more emissions intensive. If, for example, New Zealand production of steel or cement was displaced by imports, they are likely to come from countries such as Australia or Indonesia where electricity is currently 5-6 times more emissions intensive than New Zealand.

But, conclusions of negative impacts are also highly speculative. They should be taken as cautionary notes and not predictions. In any case, competitiveness is a two-sided coin and, to a large extent, competitiveness effects depend on policy developments overseas. Actual impacts will depend on how fast and how stringently climate policy is applied, both here and overseas.

Much could change with new climate policy pledges under the Paris Agreement. In the meantime, a credible long-term target would provide valuable signals to firms, if that target is accompanied by sufficient policy flexibility to be able to adapt policy settings to events here and abroad. And acknowledging that other countries are doing the same and will continue to do so.

It is worth reflecting too that most studies examining competitiveness effects – before the fact – have assumed emissions prices that, ultimately, have never come to pass. One of the reasons for this is transitional measures and exemptions to carbon pricing that followed the assessments of competitiveness effects. Policy has consistently undermined demand for mitigation and, therefore, prices have been low. This is a quandary: how to raise prices to see what they do when you believe you already know what they will do?

Contents

1. Scope, context, and approach

This report is about three countervailing forces that affect New Zealand's ability to contribute to global efforts to reduce climate change:

- competitiveness
- leakage
- innovation.

Competitiveness concerns could undermine ambition. Leakage risk should moderate ambition. Innovation is a possible way through the first two problems, but it is not easily obtained.

All three effects have highly uncertain size and can be relied upon to increase with any tightening of emissions limits. The effectiveness of climate policy will be determined by which effect dominates.

1.1. Policy context

The New Zealand Government is considering options for domestic climate change policy and long-term mitigation targets, including a target of net zero emissions by 2050.

This report will provide context for these deliberations. It addresses issues arising from current policy and targets and from increasing New Zealand's targeted rates of greenhouse gas mitigation.

Current national mitigation targets include:

- reducing greenhouse gas emissions by 30 percent below 2005 levels by 2030[1]
- reducing greenhouse gas emissions by 50 percent below 1990 levels by 2050.

Part of the deliberations over New Zealand's targets are likely to include whether or not to differentiate policy or targets for reducing methane emissions (CH_4), because they are short-lived, compared to emissions of carbon dioxide (CO_2e) and nitrous oxide (N_2O).[2]

New Zealand's principal policy lever for reducing emissions is currently the New Zealand Emissions Trading Scheme (NZ ETS). The scheme puts a price on emissions to incentivise emissions reductions. It currently applies to all greenhouse gases and all sectors, except on-farm emissions.[3]

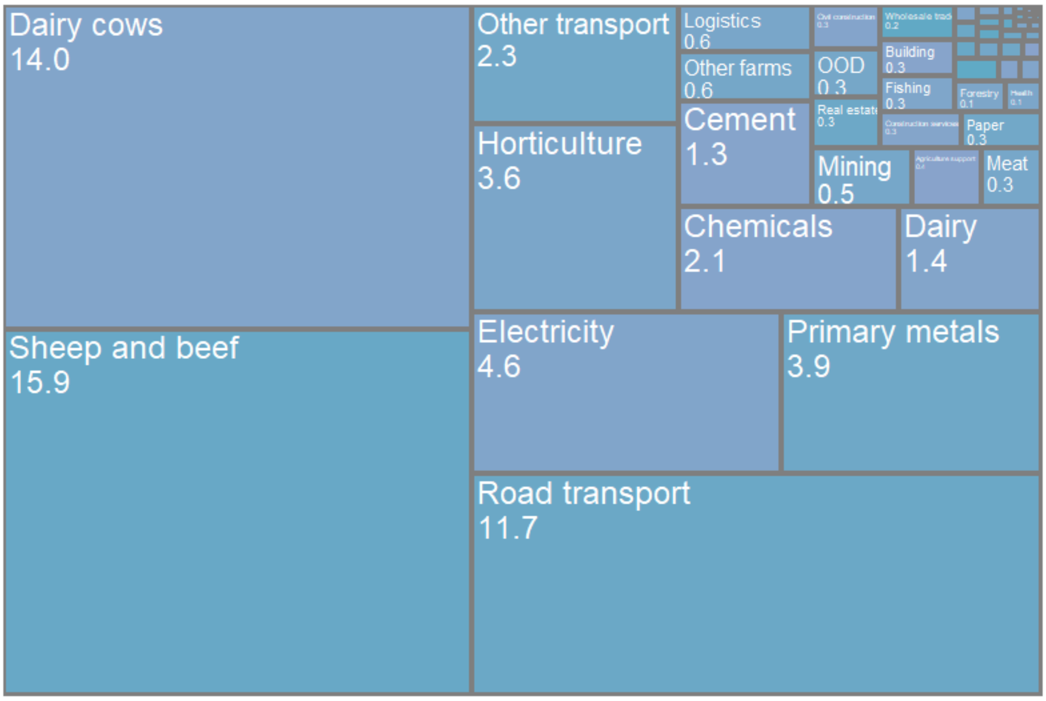
[1] Also New Zealand's nationally determined contribution under the Paris Agreement.
[2] See, for example, Parliamentary Commissioner for the Environment. (2018).
[3] Emissions are not priced but they are subject to reporting requirements.

On-farm emissions make up nearly half of New Zealand's total emissions and three-quarters of those emissions are methane from livestock (37% of national gross emissions). This is reflected in Figure 2.

The NZ ETS includes several measures aimed at reducing the economic impact of the scheme. This includes provisions to limit impacts on firms whose production is emissions-intensive and exposed to international competition.

FIGURE 2 EMISSIONS EMBODIED IN INDUSTRY OUTPUT

Estimated total mega-tonnes 2007-2016. National accounts industry definitions.[4]



It is not the purpose of this report to examine the details of transitional or assistance policy or innovation policy. However, these matters do necessarily arise in any discussion of competitiveness, leakage and innovation, so they will be discussed where necessary. As discussed in section 2, policy response and diagnosis are intimately related, conceptually. Existing and potential policy also affect experience and data, which need to be considered in any empirical analysis. It is policies, including assistance policies, which can create competitiveness concerns and stimulate or hinder innovation in the first place.

[4] Industry names shortened for presentational purposes ('Dairy' is dairy manufacturing and 'Sheep and beef' and Sheep, beef cattle and grain farming). Estimates based on methods in Allan, C., & Kerr, S. (2015) (see also Allan, C., & Kerr, S. (2016)).

1.2. Outline and approach

The focus of this analysis is on trade-exposed and energy-intensive industries that, as discussed in section 3, face the highest risks of competitiveness impacts and leakage and will need to innovate to mitigate those impacts.

The report presents estimates of emissions intensities and costs by industry over the past decade. As a first step in understanding impacts of climate policy on firms, an analysis of the impacts of the New Zealand ETS is presented. This considers changes in costs, trade flows, output, employment, profitability and investment. Undetectable impacts are expected, given the size of emissions prices in the past 10 years, and this is confirmed, tentatively, by descriptive analysis of the data.

A focus of this report is detailing actual and potential differences in climate policies and related costs in New Zealand and in competitor and customer markets for New Zealand exporters and importers. This is an addition to the existing body of knowledge, at least as far as New Zealand climate policy is concerned. Similar analyses usually pay limited regard to actual policies in other countries. This analysis suggests New Zealand firms have not faced effective costs of emissions that are high by international standards, but they have been relatively high by Asia Pacific standards.

To extend the examination of existing climate policy and cost impacts to future states of the world, and hence concerns for competitiveness and leakage risks in future, the analysis uses estimates of the carbon prices resulting from Nationally Determined Contributions (NDCs) under the Paris Agreement. These are used to evaluate potential changes in relative prices between New Zealand industries and their offshore competitors. The evaluation, while rooted in existing trade patterns and production technologies does indicate a significant widening of cost differentials and reasons to be concerned about an erosion of competitiveness and potential leakage.

The analysis includes consideration of the impacts of including on-farm emissions in future climate targets and climate policy.

The analysis of future impacts is largely descriptive and not determinative, considering data limitations and the uncertainty surrounding future economic, technological and climate policy changes both here and overseas. It is intended to provide an evidence base, rather than a definitive policy evaluation.

The analysis does not explicitly consider the impacts on firms of a net zero carbon target by 2050, but rather the dynamics of relative price changes that might impact on firm competitiveness and potential leakage and identification of the industries where those effects are likely to be most pronounced. This suffices for raising potential issues that may require a policy response. The analysis does consider potential nearer term (2030) effects on firms.

Prospects of significant differences in costs raise questions about the capacity of New Zealand firms to innovate and obtain offsetting sources of competitive advantage. Certainly, the overseas evidence provides qualified support for significant adjustment and potentially positive responses. It would be a mistake to presume that first order cost impacts tell the full story, although many evaluations conducted before-the-fact have jumped to exactly that conclusion. The analysis presented in this report defers to international experience and academic research in arguing that climate policy targets are likely to increase firm-level innovation. The key policy-relevant question, then, is the extent to which innovation can be relied upon to reduce any costs associated with mitigation.

Empirical evidence about innovation, evidence that is applicable to New Zealand and to climate policy, is hard to come by. To gain some insight into the ability of New Zealand firms to innovate, we consider general data and analyses on trends in innovation and productivity growth and conclude that this 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.

However, conclusions of negative impacts are also highly speculative. They should be taken as cautionary notes and not predictions. In any case, competitiveness is a two-sided coin and competitiveness effects depend, to a large extent, on policy developments overseas. Actual impacts will depend on how fast and how stringently climate policy is applied, both here and overseas.

Much could change as governments implement and revise their pledges under the Paris Agreement. While this is happening abroad, a credible long-term target at home would provide valuable signals to firms. Such a target will need to be accompanied by policies that are sufficiently flexible or adaptive that they can accommodate and respond to both positive and adverse events here and abroad.

The next section of the report steps through key terminology and concepts that are taken as given in the rest of the report. It also discusses some of the important conceptual limitations of the analysis in the report.

The subsequent section presents arguments as to why competitiveness concerns should be acknowledged and assessed in an even-handed manner. This is provided to make clear that the subsequent analysis, while partially speculative, is necessary for smoothing the way for climate policy progress.

2. Conceptual issues

Competitiveness, leakage and innovation are not always clearly understood. This section sets out what is meant by these terms and what is not meant. It points out that competitiveness is a firm-specific concern, which depends crucially on observations of clear cost impacts and the desirability of those impacts. Leakage is defined as being an economy-wide or global issue even if it can be assessed at a firm level. Innovation is clarified as being about application as much as invention of technology and distinctions are drawn between innovation and productivity growth. Analysis of these related phenomena is often conducted without accounting for economy-wide effects and this report is no different, which is a limitation. As such, this report needs to be considered alongside other analyses (such as CGE analysis) which do account for economy-wide effects).

2.1. Competitiveness

Competitiveness means:

> *asking whether a country's exports and import-competing industries have low enough costs to sell stuff in competition with rivals in other countries.*[5]

Competitiveness is not a meaningful concept for an entire economy. It is, fundamentally, about companies and about products and production, not countries (Krugman, 1994).

That said, in this context, competitiveness is about differences in costs of firms in different countries. Although there are cost implications of firms in the same country facing costs that are uneven – as discussed in sub-section 2.4.

Where policy impacts are concerned, including climate policy, the narrow notion of competitiveness needs to be expanded to consider three issues:

(1) will policy cause an uneven increase in firms' costs?

(2) will uneven cost increases lead to a material and sustained decline in income or production?

(3) is a decline in incomes or production socially undesirable?

2.1.1. Cost impacts

The first question is generally easily answered, with enough data. Uneven costs and prices are not the same thing as uneven climate mitigation targets. If policy does not affect firms' costs directly, it is not reasonably considered within the scope of competitiveness (see discussion below regarding economy-wide effects and non-price policies).

[5] https://krugman.blogs.nytimes.com/2011/01/22/competitiveness/

2.1.2. Income and production effects

To go from a cost impact to an income impact requires considering the dynamic response of firms, competitors and customers to changes in costs. This requires an examination of:

- whether and to what extent firms can pass costs on to customers, without losing market share
- whether firms can cost-effectively adapt to avoid cost increases.

It is challenging to know what firms will do in response to a shock in relative costs. It is in the very nature of competition that firms need to adapt to uneven changes in costs. To know what successful adaptation will look like is to know the key to commercial success. That key is not found as much as it is revealed by the fact that adaptation has worked. In other words, successful adaptation will only be apparent after the fact.[6]

Therefore, it is important to qualify that expected income or production impacts need to be material or sustained. If cost impacts or differences are small, income or production impacts are unlikely to be material or sustained. And if policy-makers started reacting to firms' relative cost differences of any size, they would undermine the positive incentives on firms to find and profit from solutions.[7]

Materiality is essentially a question of scope for cost pass-through (price increases) and impact on market share. It also depends on the overall, current, profitability of the firm. Clearly if a firm cannot pass a cost increase to its customers and its profitability is already marginal, then even a small cost increase may have a material effect on the firm.

Firms can always put up prices to pass costs on to customers, but they are likely to lose customers and income as a result, even if they do not face stiff competition. Even monopolists with substantial market power are not immune.[8] If consumer demand is at all price sensitive, then even firms with substantial market power will bear most of any unexpected cost increase, in terms of reduced profits (other things being equal).

As a rule of thumb, changes in costs will land disproportionately on the least price-sensitive party. So, if customers are price sensitive and producers less so, the producer will bear most

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[6] This is true, even where ostensibly known and cost-effective technologies or substitute products exist. Firms still need to weigh issues such as which technology to buy and when and whether to wait and see if something better comes along.

[7] This 'agency' issue is a critical issue in regulation and in economic efficiency. As soon as governments intervene to support industry, they take on the risk that the intervention was a poor one, they undermine the strong incentives that exist when people bear the costs of their own decisions, and they run the risk of passing the cost of mistakes on to entirely unrelated parties with no say or ability to affect the process. This is a recipe for increased costs to consumers and profit flowing to people who make mistakes.

[8] This basic insight flows from the idea that if firms could raise prices without scaring off some customers they ought to be doing it anyway. This then suggests that even monopolists cannot sustainably raise prices in response to external unexpected cost shocks without losing income – because they should have already been pricing in a way that extracts maximum profits. That said, this only holds if firms are already extracting maximum profit from consumers. If not, the analysis becomes much more ambiguous.

of the cost. In the international trade analysis, this is usually assessed by examining the price sensitivity of import or export demand (i.e. export demand elasticities). The presumption is that impacts on firms increase with the sensitivity of export demand to prices.

Competition also affects the ability of firms to pass on costs. The greater the degree of competition, the less firms can pass on costs. The usual presumption in international trade analyses is that markets are highly competitive and thus opportunities for cost pass-through are quite limited. However, this has to be moderated by the fact that firms can and do differentiate themselves and their products to obtain market-specific power to raise prices[9] (see Fabling and Sanderson (2015) for a relevant empirical analysis for New Zealand firms).

Another important consideration is the cost of mitigation and whether there are readily available or high probability alternatives to current practices or technologies and equipment which might be a bit costlier before the cost increase, but which can go a long way to mitigating cost shocks (if not now, in the future).

On this basis, the materiality of cost increases and scope for cost pass-through depend on:

- size of relative cost increase
- current profitability
- strength of competition
- availability of cost-effective adaptations.

2.1.3. Social desirability

Social desirability is an important consideration for two reasons. One is that policies are generally enacted to serve a purpose and, certainly in this case, policy is intended to encourage some behaviours (reduce emissions) and discourage others (increase emissions). Clearly, any impacts on firms can only be a concern if those impacts are contrary to achieving the policy's objectives or create disproportionate or regrettable negative consequences.

Secondly, declining incomes and production can be socially desirable, regardless of the policy objective. Firms are established and grow and fail all the time. This process of creative destruction – where the new and better replaces the old and defunct – is an important part of the commercial competitive process. If policy causes uneven costs which accelerate a firm's decline this may not be a problem, on balance, if that firm's decline catalyses the growth of another, lower emission or higher productivity, firm or encourages a new and innovative firm to enter the market.[10]

[9] For a relevant empirical analysis of New Zealand firms see Fabling and Sanderson (2015) who find that sensitivity of exports to exchange rates declines as product differentiation increases.

[10] This is clearly a problem for the owners and, potentially, the employees of firms that may close. There may be social policy reasons to help people faced with these kinds of adjustment costs.

2.2. Leakage

Leakage is when a reduction in emissions in one country is displaced by an increase in emissions in another country (Barker et al, 2007).[11]

Unlike competitiveness effects, leakage is not a firm-level phenomenon:

> *Effective, least-cost, global action is likely to mean emissions reductions in some countries and increases in others… It may be environmentally advantageous for a firm's production and emissions to migrate. Net changes to global emissions are what really count.* (Stephenson & Upton, 2009)

Risk of leakage can be detected by finding cases of competitiveness problems. Two of three of the potential sources of leakage rely on a competitive disadvantage from uneven carbon prices.

The three channels through which international emissions leakage can occur are:

- **trade-related** leakage, where firms with less emissions intensive production lose market share to those with more emissions intensive production
- **investment-related** leakage where industries relocate to countries with low emissions prices
- **price-related** leakage, where reduced consumption of emission intensive products, like oil, in one country causes a fall in international prices for those products and an offsetting increase in consumption and emissions elsewhere in the world.

Leakage is also similar to competitiveness in so far as it is difficult, before the fact, to know if leakage will be sustained and material. While a firm might lose market share to a more emissions intensive producer, if that other producer is in a better position to reduce emissions long term – as policy and technology evolve – then short-term leakage might give way to environmental benefits.

2.3. Innovation

Innovation means new ways of doing things, which, in this context:

- improves economic performance, at the firm or the country level or
- reduces emissions intensity of production, or
- reduces emissions in absolute terms.

Ideally, it will achieve all three.

[11] Other uses of the term leakage include project level impacts where a project to reduce emissions can cause a transfer of activity that causes emissions to increase outside the boundary of the project.

This "involves not only the generation of new knowledge – invention or discovery – but also applying that new knowledge…" (Wakeman & Le, 2015).

Economic performance, in this context, is taken to mean productivity gains. Productivity is, by convention, the market value of production with a given set of inputs.

Innovation, in contrast, is simply an activity that may or may not have any bearing on productivity. Indeed, Wakeman and Conway (2017) find that, in New Zealand, innovating firms do not achieve better productivity outcomes than other firms, even though they do experience faster output growth.

Innovation targeted at emissions reductions is no different. It may or may not achieve its objective or create useful new knowledge.[12]

Figure 3, below, summarises some of the key resource flows and incentives affecting innovation in response to climate policy, from the perspective of an individual producer. The Figure emphasises the centrality of producers in funding research (*a*) and the dependence of research funding on a firm's revenue or, with borrowing, expected revenue.

Figure 3 also highlights the centrality of relative input prices in incentivising firms to investigate new production methods (i.e. engage in research (*b*)) and to incorporate findings (*d, e*) into production in anticipation of improved productivity or profitability (*f*). Relative prices in this context includes effects of climate policy of raising the costs of using emissions producing inputs both now and in future (i.e. expected as well as current relative input prices).

There is a trade-off between applying innovation effort at emission reductions or to reducing other costs or improving product quality. In most cases this trade-off will not be 1-for-1, as emissions reductions can simultaneously reduce other costs or make a product more appealing to customers. In general, however, there is clearly a trade-off: resources that are pointed towards low emission research cannot be directed to other uses.

This makes emissions pricing and support to innovation essential parts of climate policy, because they are needed to tilt innovation effort in favour of reducing emissions. Hence the need to tilt relative input prices; although it also means that innovation effort can, in principle, be tipped too far in favour of emissions reduction.

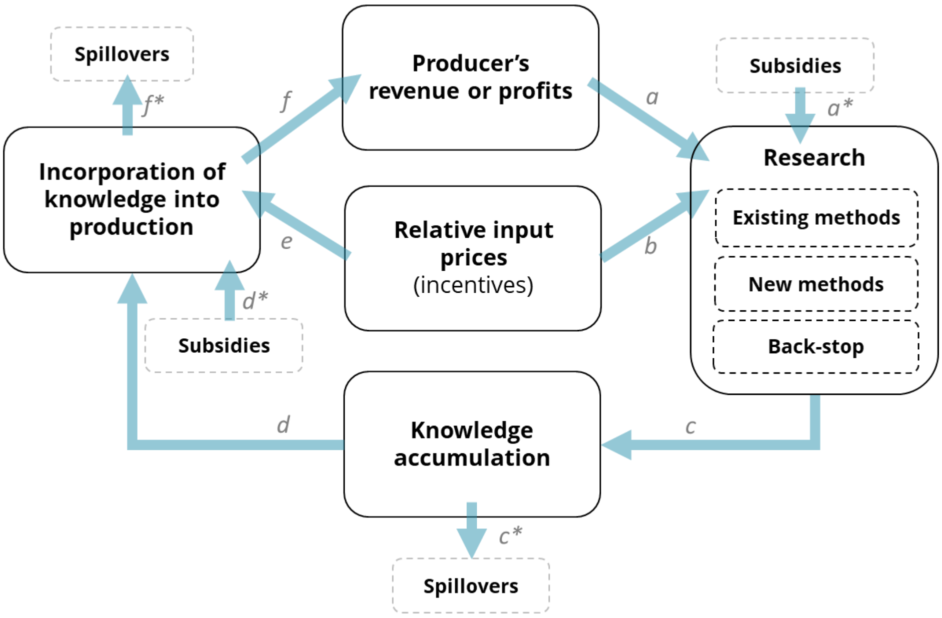
There is a range of options that firms can choose to research. One is to investigate the use of existing or known methods for improving emissions productivity (i.e. value of output per tonne of emissions).[13] This might include investigating methods that are in use by other producers, here or abroad (i.e. diffusion of existing methods). It might also include investigating an increase in the use of methods already known to the firm, such as increased

[12] This comment is not a reflection on commercial value. Useful, in this context, means successful in some sense. Not useful means of no value in either market or non-market use.

[13] The term 'methods' is used here to encompass both changes in production processes and investment in new equipment and machinery or skills.

substitution away from more emission intensive energy sources.[14] Entirely new methods might be investigated. Much depends on the scale of the problem that is to be solved. If relative emissions prices are expected to rise significantly, it may justify investigation of so-called 'back-stop' technologies. These are relatively expensive and often immature technologies, such as carbon capture and storage, but which can have a large impact on emissions.

FIGURE 3: INNOVATION INCENTIVES, OPTIONS AND RESOURCE FLOWS[15]



While innovation is hit and miss, when it hits it has important scale effects. New knowledge and learning can often be shared at low or no cost by others. These so-called 'spillover' benefits mean that the wider social benefits of successful innovation can be higher than the benefits appropriated by investors or creators of new knowledge. It also means that innovation is apt to be under-supplied, without policy intervention. This may provide justification for subsidies or other programmes which can increase research (*a**) or increase the rate at which emissions reducing methods are incorporated into production (*d**).

These spillover effects are represented in Figure 3 as outflows of accumulated knowledge (*c**) and also demonstration effects (*f**) where other producers see what is being done and can adopt similar approaches if it is proving feasible or successful.

Scale effects from spillovers mean that, without policy intervention, innovation effort will be naturally biased towards emissions intensive production wherever this is the dominant mode

[14] There is a fine line here between innovation and operational decisions. But, substitution will often require research to assess cost savings and long-term sustainability especially where there are large and unprecedented increases in the scale of use of a particular input.
[15] Adapted from Sue Wing (2006) p.550.

of production (Acemoglu et al, 2012). This provides a further justification for policy intervention to tilt the playing field in favour of emissions reduction.

2.4. Limitations

2.4.1. Crude assumptions about targets, caps and carbon pricing policies

This report addresses impacts on firms of climate policy targets and policies and the response of firms. This two-step process is both a simplification and quite artificial, especially from the perspective of long term environmental and economic impacts.

It is quite usual to work back from a price or a target to consider what the impacts might be on firms, but the impacts of targets on prices is a function of actions that firms take. If firms expect emissions prices to rise and invest in low emission technologies, then prices may not rise as much as expected because carbon constraints become less binding.

This is especially so where climate policies are formulated based on reduction targets or emissions caps and prices are adjusted (whether through taxes or trading schemes) to reflect the size of the carbon budget (metaphorically or explicitly).

Furthermore, demand for mitigation, from governments, is very often a direct result of assessments of mitigation potentials.

In economist vocabulary, prices on emissions and demand and supply of emissions are all jointly determined or endogenous.

Prices in New Zealand and the value of mitigation in New Zealand will also be affected by the actions of firms and governments in other countries, to the extent that they affect the global stock of demand for and supply of emissions reductions and emissions reducing technologies.

This analysis, and similar analyses which assess impacts of prices on firms but not firms on prices, implies that if a firm were excluded from facing a carbon cost – for reasons of competitiveness concerns – there would be no consequent effect on other firms or industries. The opposite is likely to be true. With a fixed mitigation target, if a firm or industry is exempted from action this raises the cost (the amount of mitigation required) to be taken on by other firms (unless the target is adjusted). These sorts of dynamics are potentially important, but they are not addressed in any detail in the analysis in this report.

2.4.2. Not an assessment of economic growth or general-equilibrium effects

This report is not about impacts on national income and economic growth. Nor does it purport to account for wider economic effects and macroeconomic adjustments, which would be found in other analyses such as general equilibrium analysis.

This is not to say that economy-wide effects are not important or important for this sort of subject matter. On the contrary; they matter a great deal but are being investigated by others.

Economy-wide effects are important for understanding competitiveness and leakage because of the effects that macroeconomic adjustment can have on preserving firm competitiveness at a wider social and economic cost. These effects are precisely why it was pointed out earlier that competitiveness is about products and production and not countries (or economies).

If firms' costs increase and their competitiveness is undermined, the exchange rate will adjust, and this will partially restore exporters' and importers' international competitiveness, at a cost to consumers whose international purchasing power has declined. Of course, the scale of this adjustment is somewhat ambiguous, but the direction of effect is clear.

This issue was well articulated by Paul Krugman (1994), in more emphatic terms, where he pointed out that a country can easily have very cost competitive exporters, a very low exchange rate, high levels of exports but also unsustainable debt levels and low living standards or high unemployment.

In other words, the impacts on firms of increasing costs are apt to be overstated if exchange rate adjustment is not considered, and there are limits to which firm or exporter competitiveness benefits society.

Similarly, analysis of competitiveness inevitably focusses on costs of policies that directly affect firms (like carbon taxes and prices). Where other countries do not have such policies, the implication is that those countries are, in some sense, better off. For example, if a country has a mitigation target and chooses to meet that target through subsidies. Subsidies are not costless. Either revenue needs to be raised to fund them or other services need to be cut. Either way there is a cost, but it is channelled through fiscal policy (taxation and government spending) rather than being obviously and clearly levied on firms. This is not to say that subsidies are necessarily ineffective or even more costly than emissions pricing initiatives (though this is likely). It is just to say that an analysis of competitiveness based on differences in carbon pricing policies does not equate to a judgement about whether other countries are contributing and, therefore, how much New Zealand should be doing. It is not necessarily a complete assessment of the impact of climate policies on firm competitiveness, because it does not account for potential changes in wider economic conditions because of climate policies.

These observations are similar to those that apply to assessments of fossil-fuel subsidies or agricultural subsidies. The first order impact of these subsidies would show that they improve firm competitiveness at the expense of the competitive position of more productive overseas rivals. A more complete assessment would find that these subsidies are fiscally costly and reduce industry productivity and underlying competitiveness and are generally unsustainable both financially and environmentally.

Similar, but less negative, comments can be made about, for example, feed-in tariffs and direct programmes to support abatement. That is, countries will bear costs of abatement, just not in a way that changes marginal prices (see OECD, 2013).

2.4.3. Analysis based on industry averages

The analysis in this report works on averages – industry average intensity, industry level trade data, industry level productivity growth. This means that its observations are very general.

This is, in some senses, unavoidable and desirable. It is unavoidable in the time available. It is desirable in so far as the discussion would be far too complicated if every firm were analysed one-by-one.

2.4.4. Limited data and NZ insights into innovation response

Forward looking analysis of innovation effects is always going to be on shaky foundations. However, insights can be gained by looking at experiences here and abroad. We draw much of our insight from a rapidly growing research literature, internationally. Admittedly, these have imperfect applicability to the New Zealand context, given differences between New Zealand's emissions profile and scale of major emitting sectors such as livestock agriculture.

We also consider empirical evidence from New Zealand on industry productivity growth and innovation, and we analyse responses of industries to energy price shocks. These are not directly related to climate policy and do not account for important potential changes to the global availability of new technologies and knowledge regarding emissions mitigation. So, our analysis is by no means complete.

3. Acknowledging competitiveness concerns

The core of this report is competitiveness concerns. They are where leakage risk begins, and they create additional demands on firms to innovate, to overcome competitive disadvantage. Competitiveness concerns are inescapable and competitiveness impacts are inevitable in a real world of justifiably uneven climate policies and emissions costs. Competitiveness impacts are often overstated but need to be acknowledged and addressed in an even-handed manner because they are real.

3.1. Concerns about competitiveness and leakage are inescapable

Climate policy inevitably raises concerns about comparability, equity and effectiveness. Who should do what, when and how much.

Part and parcel of these concerns is the worry that companies will be at a competitive disadvantage if domestic policy moves faster or further than in other countries. If that happens, incomes, wages or employment could decline, and they may decline unnecessarily.

The worst-case concern is that, when economic activity migrates, global emissions may not fall at all and may even increase. This is known as leakage, which threatens to undermine domestic emissions targets and climate policy initiatives.

Concerns about competitiveness and leakage arise because of fundamental global coordination problems that are at the heart of climate policy. That is, who should do what, by when and how much. They are fundamentally inescapable.

One aspect of this coordination problem has been resolved by the passage of the Paris Agreement. There is now broad agreement that everyone should act, even if actions will differ according to different responsibilities and capabilities. That is, all countries will do something, as soon as they can and as much as they are able according to their own assessment of ability to contribute.

This still leaves the New Zealand Government, along with other governments, with a difficult coordination problem. Around the world, climate policy will be a patchwork. Countries will move in different ways and at different speeds. So, whether revising NDCs or implementing domestic policy, policy-makers will have to make progress in a world of uneven action.

3.2. Policy makers need to get comfortable with a world of uneven action

The New Zealand Government should not shy away from the fact that action will be uneven. This is a social and legal fact, embedded in the international architecture. Furthermore, it is there for good reason. Broad agreement to act required broad agreement to act as countries are able. Common carbon prices are not likely to be 'optimal' from a global welfare perspective (Chichilnisky & Heal, 1994), even if they could be applied, which they could not.

Besides, uneven action is a matter of practical reality. Differences are everywhere, and they are not peculiar to climate policy. Economic and political institutions differ. Trade and economic policies differ. Resources, wealth, incomes, knowledge and technologies all differ. Harmonised policy would not have a harmonised effect. Indeed, institutions and climate policies are likely to be more effective when tailored to local circumstances. Even if it were desirable to harmonise climate policy, there simply is not sufficient information or coordination mechanisms to make it happen.

Some degree of increased harmonisation is desirable though. There are many differences that can be managed and reduced to good effect, such as global access to energy efficient and emissions-reducing technologies. There are economic and environmental benefits to aligning carbon prices, where possible, to ensure that costs of mitigation are minimised and economic activity takes place where it is most efficient from an economic perspective and an environmental perspective.[16] However, the point is that differences are a reality in most things, and climate policy is no exception.

Debates over climate policy and competitiveness too often proceed as a dichotomy. On one side, competitiveness concerns are seen to be rooted in emissions intensive activities that need to be phased out, whatever the cost; on the other, those who would protect their competitive position and minimise any differences in policy-induced costs.

Both positions are understandable and both positions can be defended. Emissions do, indeed, need to be reduced and for some that will impose a cost, but that cost ought to be proportionate to benefits that are being delivered as a result.

A middle ground is to start from the view that differences exist, and they need to be understood and managed – at the service of an over-arching goal of avoiding dangerous climate change.[17] This should help to bring perspective to debates about competitiveness and leakage.

Competitiveness concerns are easily overplayed, but they are not imaginary. Whether commercial costs are large, or environmental outcomes weak, depends critically on:

- who New Zealand companies compete with
- where their key export markets are located
- differences in stringency and scope of climate policies between NZ and other markets
- how New Zealand companies respond.

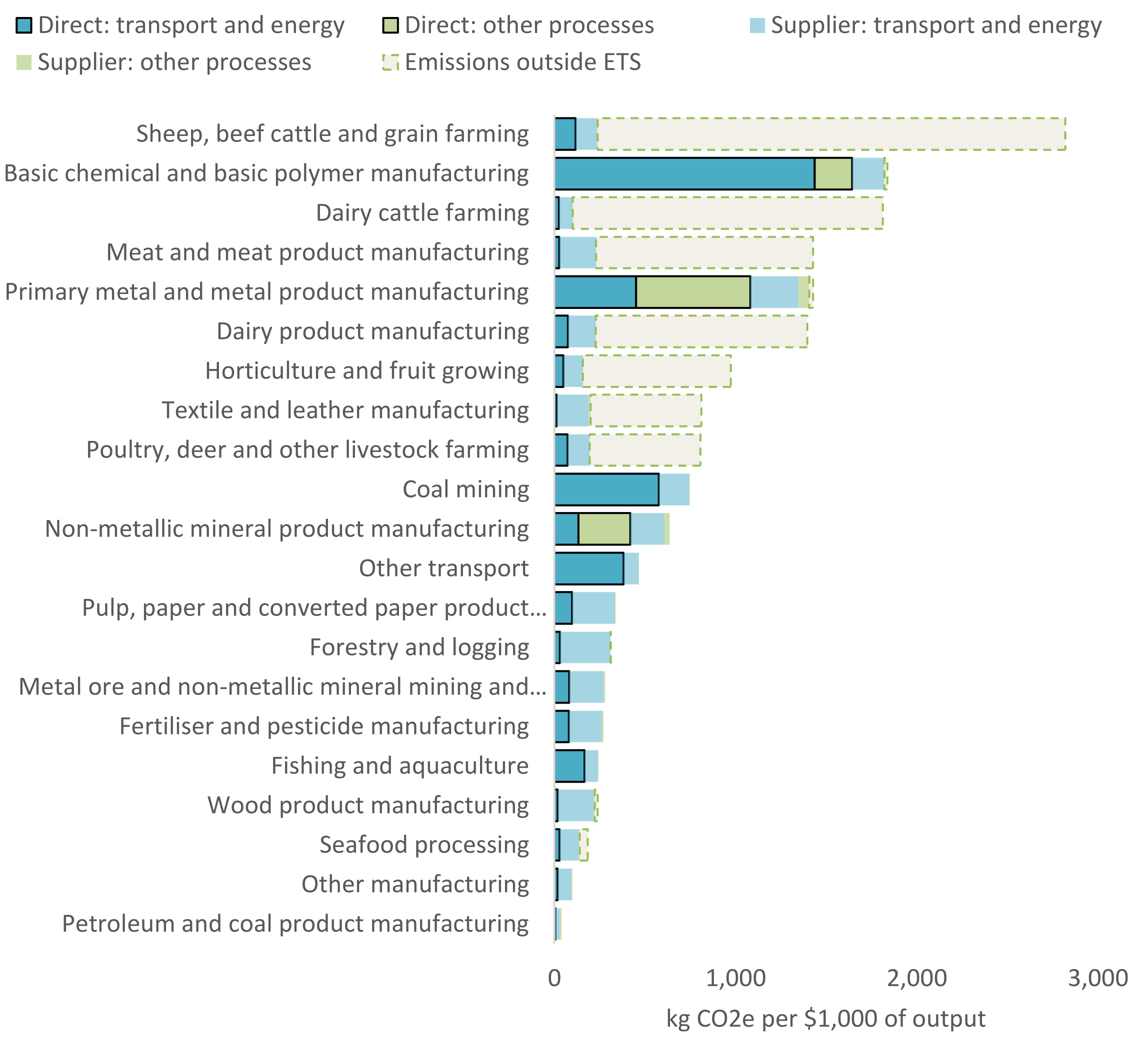
[16] This differentiation between economic and environmental perspectives is merely a rhetorical device. A well-rounded economic perspective should, in our view, involve an environmental perspective and vice versa.
[17] The day may come in which the reverse may be true. but for now, it is not.

4. Emissions intensive and trade exposed industries in New Zealand

Figure 4, below, provides a summary of the emissions intensity of industries and firms that, in principle, would be most at risk of competitiveness issues given their emissions intensity and trade exposure.

FIGURE 4: EMISSIONS INTENSITY BY INDUSTRY

Estimates, 2017, for industries with import or export trade exposure



These are the sectors for which leakage risk is also greatest and where innovation needs to occur if competitiveness is to be sustained.[18]

These industries differ a great deal in terms of characteristics, customer bases and trade profiles. Some are relatively unaffected by current climate policy (farms). Some have comparatively low emissions intensity but produce highly tradable commodities not easily differentiated by producers (petroleum refining). Some are most affected by their own direct emissions (basic chemicals) and others are likely to be affected by increasing costs from their suppliers (textiles, wood products).

These industries collectively make up:

- 13% of GDP
- 11.5% of labour income.
- 76% of exports of goods and 55% of total exports of goods and services
- 19% of imports of goods and 11% of total exports of goods and services.

Only one service industry was identified as emissions intensive and trade exposed: the 'Other transport' sector, consisting primarily of scenic flights and similar specialised transport services.

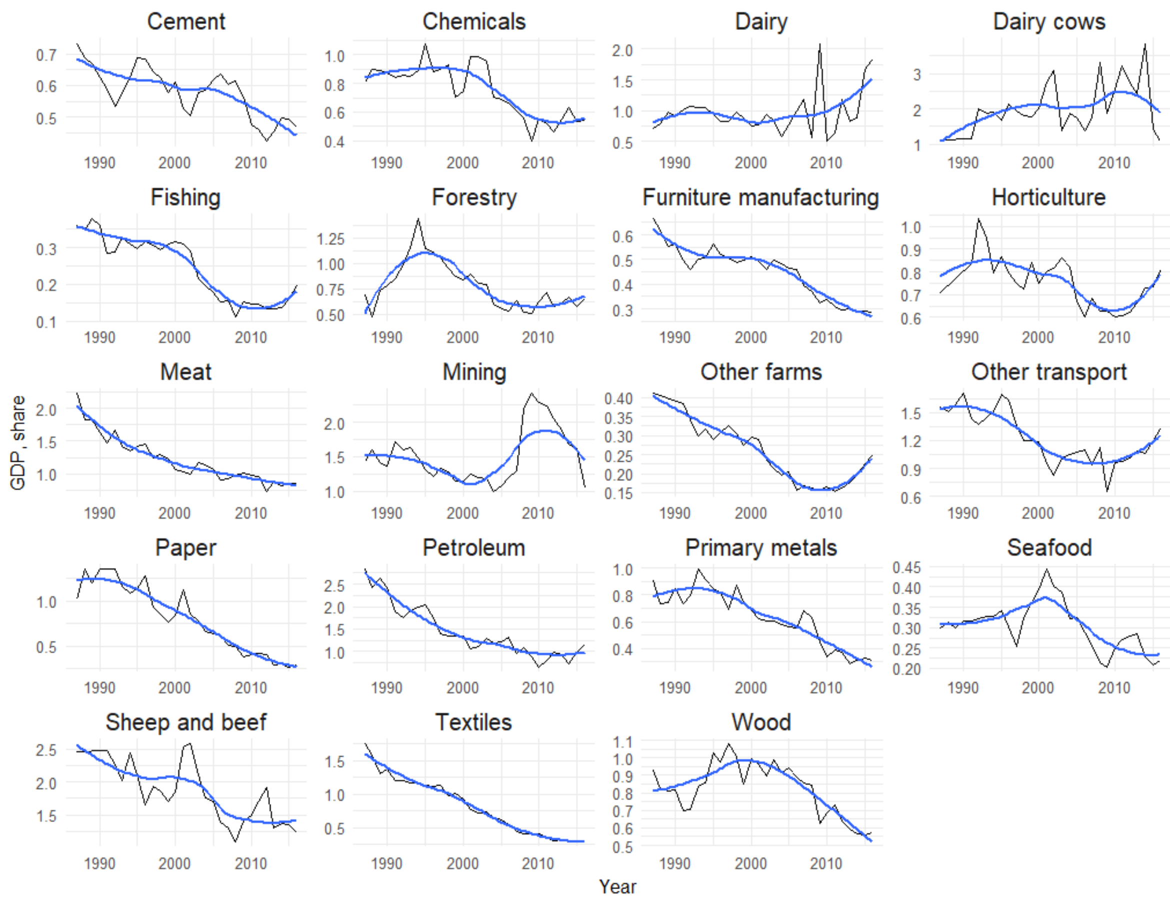
Almost all New Zealand's emission intensive and trade exposed industries have been declining for many years in terms of share of the overall New Zealand economy (see Figure 5). The one possible exception is the dairy industry, which has increased its share of the economy in the past decade or so.

Many of these industries have been growing, but growth has not kept pace with growth in other parts of the economy – i.e. in services industries. That said, a few manufacturing industries have been declining in absolute terms in the past decade or so: pulp and paper manufacturing and textile manufacturing. The primary metals industry has also been in decline since the global financial crisis because of a tough economic environment for steel production with relatively low prices, over-supply of production capacity globally, low margins and reduced competitiveness of New Zealand steel production. This will be touched on further below in discussion about international competitiveness and trade.

[18] To analyse emissions intensity and costs facing New Zealand industries we have adopted the approach in Allan & Kerr (2015). This allows allocation of emissions to as detailed a level of industry data as possible (see Appendix 1) with publicly available data. Criteria for determining industries that are emissions intensive and trade exposed is also discussed in Appendix 1.

FIGURE 5: FOCUS SECTORS, LONG TERM GROWTH TRENDS

Share of GDP by sector with smoothed trend lines in blue



4.1. Competition and international trade

4.1.1. Competition and scope for cost pass-through

Most these industries are subject to significant international competition. Most of New Zealand's emissions intensive sectors are major exporters, and the majority are predominantly focussed on export markets. The average trade intensity of the emissions intensive sectors shown here is 77%.[19] Most of these industries export relatively 'homogenous' (undifferentiated) products.

Export demand for minerals and manufactured industrial products is estimated to be most sensitive to price increases. This is illustrated with the export demand elasticities in Table 1. Petroleum products have the highest price elasticities, with demand declining by 20% for every

[19] The value of trade (exports plus imports) relative to gross output.

1% relative increase in prices. Primary products tend to be less price sensitive with, for example, demand for horticulture products declining 1.2% for every 1% increase in prices.[20] However, demand for all emission intensive exports appears to be reasonably sensitive to price, such that it is unlikely that exporters could profitably increase prices to offset cost increases (at least not very easily and not on a sustained basis).

TABLE 1: INDUSTRY EXPORT ELASTICITIES AND EMISSIONS INTENSITY

Industry	**Indicative export demand elasticity**[21]	**Emissions intensity** (kg CO_2e per $1,000 of output)
Horticulture and fruit growing	1.2	974
Fishing and aquaculture	2.0	241
Dairy product manufacturing	2.8	1,395
Seafood processing	3.3	185
Textile and leather manufacturing	3.7	812
Meat and meat product manufacturing	5.1	1,428
Pulp, paper and converted paper product manufacturing	5.2	337
Forestry and logging	5.5	309
Wood product manufacturing	5.5	239
Fertiliser and pesticide manufacturing	6.0	270
Primary metal and metal product manufacturing		1,428
Iron and steel (direct intensities)	8.0	1,165
Other metals (direct intensities)	16.0	568
Basic chemical and basic polymer manufacturing	11.9	1,838
Non-metallic mineral product manufacturing	16.0	636
Other manufacturing	16.8	100
Coal mining	20.0	747
Petroleum and coal product manufacturing	20.0	36

Two of the industries analysed in this report have relatively low export trade intensity and relatively low import competition, in terms of actual current trade flows. As shown in Figure 6 and Figure 7, these are cement (a majority of emissions in non-metallic mineral manufacturing, consisting of cement, glass and ceramics production) and the part of primary metals related to raw steel production (as opposed to aluminium, which is the other major part of primary metals). These industries are, for the most part, domestically focussed.

[20] This result accords with anecdotal evidence that Zespri receives a price premium for its products. It may also be affected by New Zealand fruit growers' comparative advantage in meeting demand for fruit during the northern hemisphere winter – such that competitive supply response is weaker compared with other non-seasonal and highly storable products like petroleum and manufactured goods.
[21] NZIER (2011). Product export elasticities assigned to related industries. Expressed here in absolute terms.

However, there are reasons to believe that these industries and their products face potentially significant international competition if domestic or external cost shocks are sufficiently large.

FIGURE 6: EXPORTS OF EMISSION INTENSIVE PRODUCTS

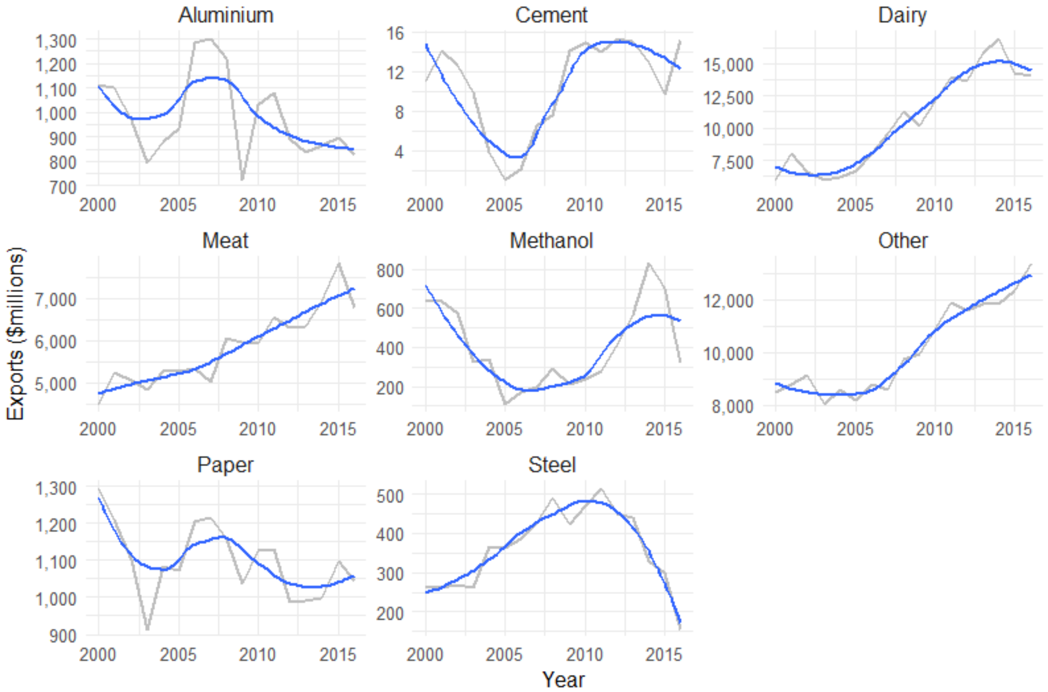
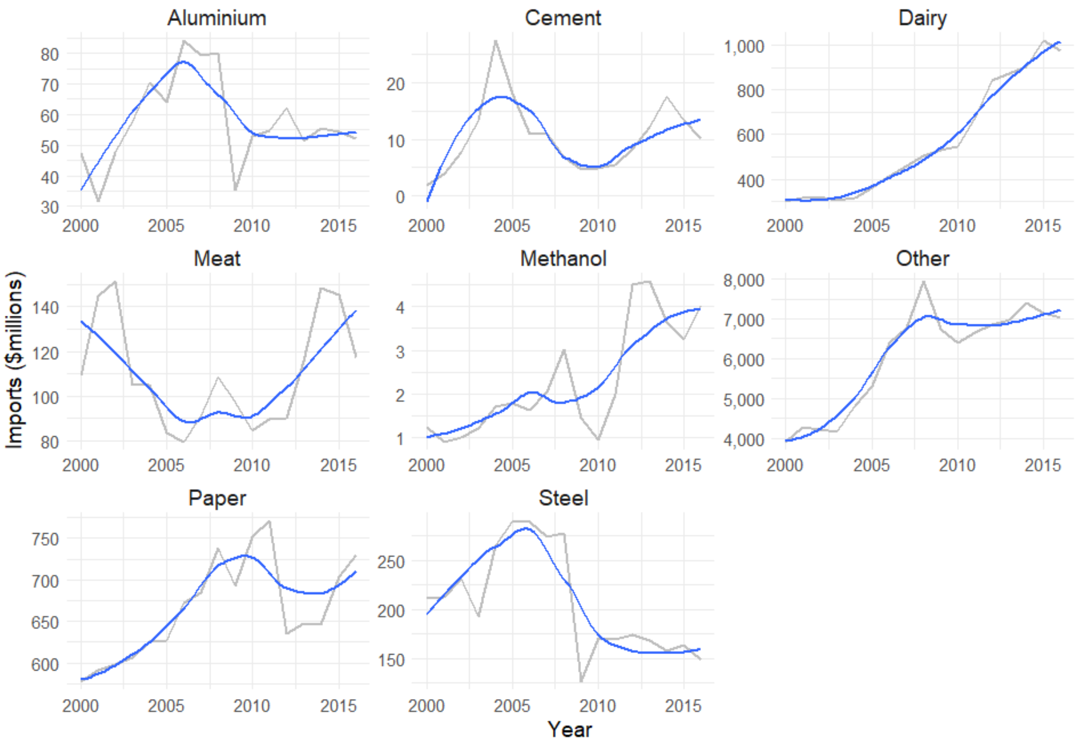


FIGURE 7: IMPORTS OF MAJOR EMISSION INTENSIVE PRODUCTS



4.1.2. Major markets

A majority of exports of emission intensive industries goes to countries in the Asia Pacific region and, if weighted by emissions, China makes up half of the market for emissions intensive exports from New Zealand (see Table 2).[22]

TABLE 2: CURRENT MARKETS FOR EMISSION INTENSIVE GOODS

	Market shares of emission intensive exports			Export value
	Shares of emission intensive exports	Weighted by emissions	Weighted by ETS emissions	2012-2017, $b
China	25.5%	51.4%	51.5%	46.9
Australia	11.2%	11.8%	11.6%	20.5
USA	9.4%	9.8%	9.7%	17.2
Japan	7.2%	7.2%	7.2%	13.3
Korea	3.9%	3.9%	3.9%	7.2
United Kingdom	2.5%	2.5%	2.5%	4.7
Indonesia	2.1%	2.1%	2.1%	3.9
Netherlands	1.7%	1.7%	1.7%	3.1
Germany	1.5%	1.6%	1.6%	2.8
India	1.1%	1.2%	1.2%	2.1
Italy	1.0%	1.0%	1.0%	1.8
Canada	1.0%	1.0%	1.0%	1.8

4.1.3. Significant firms

Several of New Zealand's emission intensive and trade exposed sectors contain very few firms, or a few very large firms, that do not face much competition at home. Indeed, many are single plants owned by single companies. This includes[23]:

- Primary metals:
    - New Zealand Steel (Glenbrook and Otahuhu, Auckland)
    - NZ Aluminium Smelters (Tiwai Point, Southland)
- Non-metallic mineral manufacturing, where emissions are dominated by cement production, of which Fletchers Golden Bay cement (Portland, Northland) is the only producer
- Basic chemicals: dominated by methanol manufacturer Methanex (Taranaki) and also Balance Agri-Nutrients (urea production)

[22] For an explanation of how these trade figures are constructed and trade matched to industry output, see Appendix 1.

[23] Other sectors are similarly concentrated, in terms of asset ownership, such as Pulp and Paper (three major firms) and dairy manufacturing has a significant dominant firm in Fonterra, although the industry has seen considerable reductions in firm concentration in the past two decades.

- Petroleum product manufacturing, dominated by Refining NZ (Marsden Point, Northland)

These industries and firms are often selected for study internationally, in terms of competitiveness effects and risks of leakage because, except for NZ refining, all have high direct and process-based emissions with limited opportunities for substitution or significant mitigation in the foreseeable future.

New Zealand Steel's raw steel production at Glenbrook has been under review by its Australian-based parent company several times in recent years, most recently in 2016. The firm was significantly affected by the global financial crisis and has made several significant changes in recent years to improve productivity – mainly focussing on cost control but also through investment, including the purchase of Pacific Steel, which consolidated steel production in New Zealand.[24] Bluescope has classified its NZ steel manufacturing, which includes exports to the Pacific Islands, as 'commodity' and well down the ranks of profitability for Bluescope. Import substitution is a constant threat, especially with excess capacity globally. Furthermore, excess capacity limits the likelihood that carbon pricing will be applied to the sector in other parts of the world, because profitability is already under considerable pressure and governments will want to avoid the risk that carbon prices will cause plants to close.

The aluminium smelter at Tiwai has similarly come under pressure in recent years whenever international prices are low or the New Zealand exchange rate is comparatively highly valued. The smelter exports almost all its production.

In the basic chemicals industry, production and profitability is significantly affected by relative prices for gas – domestic prices versus overseas and international prices. Methanex is export-focussed, while Ballance serves domestic demand for agricultural nutrients and faces significant import competition. When costs in New Zealand rise, production of urea will tend to decline because imports become cheaper. For Methanex, in the past, high domestic gas prices and uncertain supply have caused the company to mothball New Zealand production.

The cement industry has, in recent years, shifted from being almost entirely dependent on domestic production to an industry based on both import and domestic production. In 2016, Holcim closed its cement production plant in the West Coast – which was old and not very efficient – and declared it would engage in import and distribution instead.

[24] NZ Steel produces raw steel from iron ore and iron sands using a rotary kiln (which is highly emissions intensive, mainly due to the use of coal) and Pacific Steel produces steel from an electric arc furnace using scrap steel (although consolidation means that Pacific Steel, which makes steel wire and rods, is likely to source raw material from NZ Steel's Glenbrook plant).

5. Impacts of existing policy on firm competitiveness

5.1. Expected impacts

5.1.1. A large number different effects are possible

The effects of climate policy on firms, and indeed policy in general, are not straightforward and require tracing a number of competing effects from source to impact. As shown in Table 3, cost impacts are a first-order pre-requisite for competitiveness effects, but the implications of changes in costs are mediated by firm responses. Measuring cost impacts accurately generally requires understanding indirect costs, such as supplier costs, as well as direct costs on the firm. This also means accounting for responses of suppliers to their cost increases.

Cost increases can also cause quite different impacts on different measures of firm performance. Profitability is a natural choice of measure because it points to the sustainability of firm production and potential third-order environmental effects like leakage. However, even where profitability is maintained or improving, other measures may deteriorate such as investment or employment and labour income. Employment may decline, while profitability increases, if firms respond to cost increases by substituting capital equipment for labour. Investment may decline even as profitability increases if increased costs cause firms to delay capital replacement or improvements in plants and machinery.

Consequently, analysing competitiveness requires analysing several different dimensions of firm behaviour and responses.

TABLE 3: POTENTIAL COMPETITIVENESS AND LEAKAGE EFFECTS

1st order effect	2nd order effects		3rd order effects		
Cost impacts	**Firm responses**	**Economic outcomes**	**Technology outcomes**	**International outcomes**	**Environmental outcomes**
Changes to relative costs (direct and indirect costs).	Production volume. Product prices. Productive investments. Investment in abatement.	Profitability. Employment. Market share.	Product innovation. Process innovation. Input-saving technologies. Total-factor productivity.	Trade flows. Investment location. Foreign direct investment (FDI).	Pollution levels and intensity. Pollution leakage.

Source: Dechezlepretre & Sato (2017)

Third-order effects, such as innovation in production processes and energy efficiency or substitution to lower cost (lower emission) inputs, can also affect impacts on firms. Those impacts do not necessarily need to be peculiar to individual firms either, as firms learn from experiences of others.

These third order effects are hard to identify because, from a purely observational point of view, it is possible for firms to adapt their output mix towards less emissions intensive products, which look like changes in emissions of production when, in fact, it means a different kind of production. This is an issue when analysing industry level data or financial data.

A change in product mix that minimises costs and supports profitability will offset competitiveness effects at the firm level, but it is hard to draw conclusions about the extent to which this relates to environmental improvements or reductions in resource use if there has been a change in output mix.

Properly accounting for firm responses up and down the supply chain generally requires detailed case studies or the use of general equilibrium analysis, which are not part of the analysis for this report.[25] Consequently, the impacts shown here are only approximations to impacts. The direct and indirect cost impacts being considered can be thought of as approximations to 'maximum' effects.[26]

5.1.2. Overseas evidence points to potential positive effects

Evidence from overseas experiences with carbon taxes and emissions trading suggests that there is no or very little effect on firm competitiveness and, in some cases, regulated firms do better than those who are not regulated or face smaller carbon costs.

Findings from studies, mainly in Europe, include improvements in firm productivity and profitability, albeit alongside some evidence of declining employment (Commins et al, 2009). Most research finds that emissions prices do not have any effects on firm competitiveness (Arlinghaus, 2015; Martin, et al, 2016). This may be because firms adapt to cost changes, such as by substantially improving energy efficiency (Martin et al 2014).

Studies from elsewhere in the world are less likely to be based on greenhouse emissions policies but assess the impacts of other environmental regulations. Their results are similarly equivocal but appear somewhat more likely to report negative effects on firm performance. Greenstone et al (2016), for example, found that air quality regulations in the United States led to a 4.8 percent decline in manufacturers' total factor productivity levels.

Those findings are from studies that examine firm level impacts. Other studies based on aggregated data are even more likely to find at least some negative impacts (see also the discussion below on international linkages and analysis of trade and investment effects), although not universally. In a 2017 study of environmental policies on investment, Dlugosch and Kozluk (2017) found a small negative response of investment to energy prices but an increase in investment in energy intensive industries. The latter effect accords with local

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[25] General equilibrium analysis is being considered in a parallel research project.

[26] As in Numan-Parsons et al (2010). However, this is not strictly correct, because in some cases costs may rise by larger amounts than are shown here. In principle, firms or their suppliers may pass through more than 100% of costs, and if a local supplier reduces production, cost increases from sourcing products offshore could mean cost increases that are larger than a simple pass-through analysis would suggest.

observations, such as substantial investment in generating plant at Norske Skogg (as discussed below).

This difference between aggregate (macro) and micro effects is important because it is micro successes, in response to regulatory cost changes, which are expected to drive improvements in environmental outcomes over the long term. If, overall, some firms face negative effects, this is less of a concern if there is evidence that firms are capable over the longer term of adapting and maintaining productivity while reducing emissions.

Many studies do show variable impacts across industries with some faring worse than others, but the differences across industries do not seem to correlate with industry emissions intensity and cost impacts quite as much as one might expect (and policy intends). There is some correlation, with cement and basic metals being amongst the industries that do less well, but the correlation is not as strong as one might expect, suggesting that something else is driving the results.

The most obvious explanation for these findings is that firms adapt and innovate in response to climate policy. However, this is hard to square with simple economic interpretations of firms as profit maximisers (with 20:20 foresight where no value is left lying on the ground). It begs the question: why do unregulated firms not do the same as the regulated firms and still come off better than their regulated competitors? Or is it that there is simply more than one way to meet market demand, such that climate policy causes a change, with no negative effect?

The jury is out on these questions, but there are several reasons why climate policy might cause firms to adapt and innovate in unexpected ways.[27] These include (Lanoie et al, 2011):

- **Organisational and informational problems** where managers do not innovate because it means they must work harder and owners cannot always observe how much effort that could be putting into improving efficiency. Environmental regulation creates external independent demands for efficiency improvement, which managers are compelled to address
- **Bounded rationality**, where people are focussed intently on doing what they do at the exclusion of opportunities for improvement, which go unnoticed until external regulation causes them to look outside their usual environment for new solutions
- **Difficulties verifying value,** where firms have a comparative advantage in, for example, sustainable production and consumers would pay for that if it could be verified. In the absence of trustworthy independent verification mechanisms, the firm cannot prove their bona fides and consumers are not willing to pay because of the uncertainty. Regulation can provide a means of revealing the firm's sustainability to

[27] These various rationales for potential positive effects, amongst others, have arisen to explain what is referred to as the Porter Hypothesis. This hypothesis is that firms will respond to positively to regulation and in ways which may improve their competitiveness and partially offset costs of regulation (the weak version) or more than offset regulatory costs (the strong version) (Porter and van der Linde, 1995).

otherwise suspicious consumers. A related example is strategic competition where firms might choose sustainable production precisely because it distinguishes their products and opens opportunities to charge higher prices

- '**First mover' advantages**, where firms that are prompted to find new solutions to problems, or can profitably trade on their sustainability credentials, find themselves at the forefront of an emerging and profitable market.

Less favourable interpretations also include that, in practice, firms pass through costs and receive free emission allowances and other assistance, and, in combination, this leads to windfall gains in profits (e.g. Fabra & Reguant, 2013; Kirat & Ahamada, 2011; Bushnell et al, 2013). De Bruyn et al (2010) found that, during the early phases of the EU ETS, refineries and steel producers fully passed through their emissions costs into output prices.

These studies underscore the idea that pass-through is an important determinant of competitiveness effects, and pass-through interacts with transitional policies. It also reflects the fact that transitional policies (allocation of free emissions) tend to be overly generous, on average, more than offsetting cost impacts and competitiveness effects.[28]

5.1.3. Analysis of international trade effects is less positive

Firm-level studies have not explicitly examined impacts on international trade. The one exception to this is Martin et al (2014) who, in their examination of the UK Climate Change Levy, found that trade intensive producers responded more strongly to cost increases than other firms but did not experience any negative effects.

Studies that analyse trade impacts are generally based on more aggregated data (as is often necessary for analysing trade effects properly), and they often, but not always, find negative impacts of climate or environmental policies on trade flows.[29] One example is analysis by Aldy and Pizer (2011) of impacts of increased energy prices where findings include a 1%-1.5% increase in net imports for every 10% increase in relative energy prices (varying by industry). Sato and Dechezlepretre (2013) use a more robust data set to investigate the same relationships and find a similar sized effect. Both studies find larger effects for energy intensive manufacturing industries and smaller effects for primary producers.

Several studies have also investigated the so-called 'Pollution Haven Hypothesis', which is related to leakage and suggests that commerce and emission will migrate to countries with low emissions quality. There is mixed evidence for the Pollution Haven Hypothesis, mostly put down to varying methods and difficulties identifying causal effects. Timiliotis & Koźluk (2016), using a model of international trade in value chains, suggest that there is some evidence that countries do lose comparative advantage in polluting industries in the presence of stringent

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[28] For an empirical analysis of the EU ETS allocations see Martin et al 2014. For an analysis demonstrating the effects of oligopolistic competition and price pass-through on competitiveness see Smale et al (2006).
[29] These studies may contain bias because of difficulties controlling for unobservable factors, as compared to, for example, quasi-experimental methods. However, it is not possible to say what the direction of effect of this bias might be.

environmental policies, although, overall, environmental policy is not a strong driver of trade flows.

In a study of environmental regulation across Canada, Mexico and the United States, based on relative expenditure on pollution abatement and control expenditures, Levinson & Taylor (2008) found evidence of an increase in net imports due to increased environmental regulation.

In terms of overseas investment and the investment channel for leakage, Kozluk & Garsous (2017) find that increases in energy prices, related to environmental policy, cause increases in outward direct investment. This provides some evidence that investment is diverted to avoid environmental policy costs but could also indicate that policy causes an increase in the stock of investment and knowledge at home followed by diffusion of this knowledge abroad.

An exception, of some relevance to New Zealand, is the analysis by Rivers & Schaufele (2014) of agricultural trade in Canada where they find that the introduction of the British Columbia carbon tax had no effect on agricultural trade.

Panhans et al (2017), in an empirical analysis of manufacturing firms' location decisions, find that electricity price differences have an economically significant effect on location decisions. A 1% reduction in electricity prices in a country increases the likelihood of a firm re-locating there by between 0.5% and 1% (varying by country). However, they also show that electricity price differences have a much smaller effect on firms' decisions to relocate altogether. The authors speculate that this may reflect high costs of relocation, especially in capital-intensive industry when a manufacturer's existing plant still has useful life left. They reason that firms are not inclined to relocate unless input costs rise significantly.

5.1.4. Predictive studies are most pessimistic

Predictive studies – those based on theoretical models and empirical calibration – tend to predict much larger effects of climate and environmental policy changes than are observed in ex-post studies.

Carbone and Rivers (2017), in a summary of computable general equilibrium analyses, note that these studies find leakage rates between 10% and 30% of emissions reductions. They also find that 20% reductions in emissions cause a 5% reduction of output in emissions intensive and trade exposed industries and a 7% reduction in exports.

Industry level or 'partial equilibrium' analyses tend to be even more pessimistic, partly because they preclude offsetting effects such as exchange rate adjustments (see, for example, Ponssard and Walker (2008)).

Some of the analysis that follows is predictive analysis. So, given ex-post evidence to date, the numbers that are presented in terms of future impacts should be read with considerable caution.

That said, one of the reasons that predictive studies are wrong is that they generally predict policy effects without accurately predicting how policy will be applied. As mentioned above, industry assistance has generally been quite generous if not overly generous (in the case of the EU ETS). So, it is unclear if predictive studies have been wrong about potential competitiveness effects or simply wrong about policy decisions.

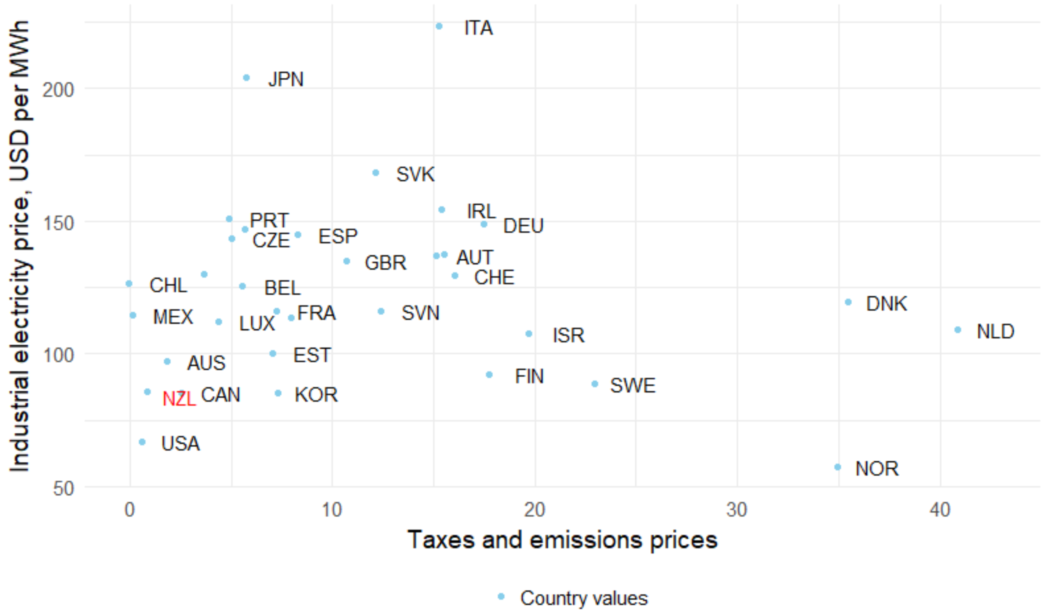
5.1.5. Climate policy does not exist in a vacuum

Firm competitiveness is affected by numerous factors. Even in the case of electricity prices, which are directly affected by climate policies, there is remarkably little relationship between effective carbon rates and electricity price levels (see Figure 8).[30] This is perhaps unsurprising as countries have different:

- natural resources and generating fuels
- levels of demand growth
- technology vintages and efficiency
- local costs, such as wages
- regulatory frameworks.

These sorts of factors affect every sector in the economy and the competitiveness of New Zealand firms and industries.

FIGURE 8: RELATIVE ELECTRICITY PRICES INFLUENCED BY MUCH MORE THAN TAXES AND CARBON PRICES



[30] Sato et al (2015) report that most of the variation in <u>changes</u> in energy prices is due to changes in tax rates. However, levels of electricity prices appear to vary for other reasons. Their data covered 12 industrial sectors and 48 countries for the period 1995-2011.

Trade flows are similarly affected by a wide range of factors. Distance, for example, affects trade flows a great deal and more so than simple shipping costs would predict. Other factors affecting export flows include common language, infrastructure quality and quality of institutions in terms of property rights and financial market sophistication (see Law and Genç, 2014).

High performers also select exporting for themselves (Fabling et al, 2012) so they are, presumably, more capable than other firms of solving the commercial problem of higher costs. This presumption is supported in the climate policy context by findings in the UK that firms with high trade intensity were better able to manage their energy efficiency in the face of quite large energy cost increases (Martin et al, 2014).

This is not to say that these higher prices have created competitiveness issues for New Zealand firms. First, other countries effective carbon rates have been increasing (as discussed later in this report). Second, New Zealand trade to countries with low carbon rates has been growing rapidly, particularly to China. This underscores that prices on emissions are not the determining factor in trade flows. Furthermore, as indicated in Figure 8, taxes on emissions and energy use are not necessarily correlated with relative input cost levels faced by firms.

Of course, if climate policy does increase firms' costs, then that is still one more thing that can reduce the attractiveness of their goods and services to offshore customers. Consequently, it is natural for people to be concerned that their competitiveness will be reduced. However, overseas evidence suggests that firms overcome these effects (although this may be uncertain before the fact and requires effort).

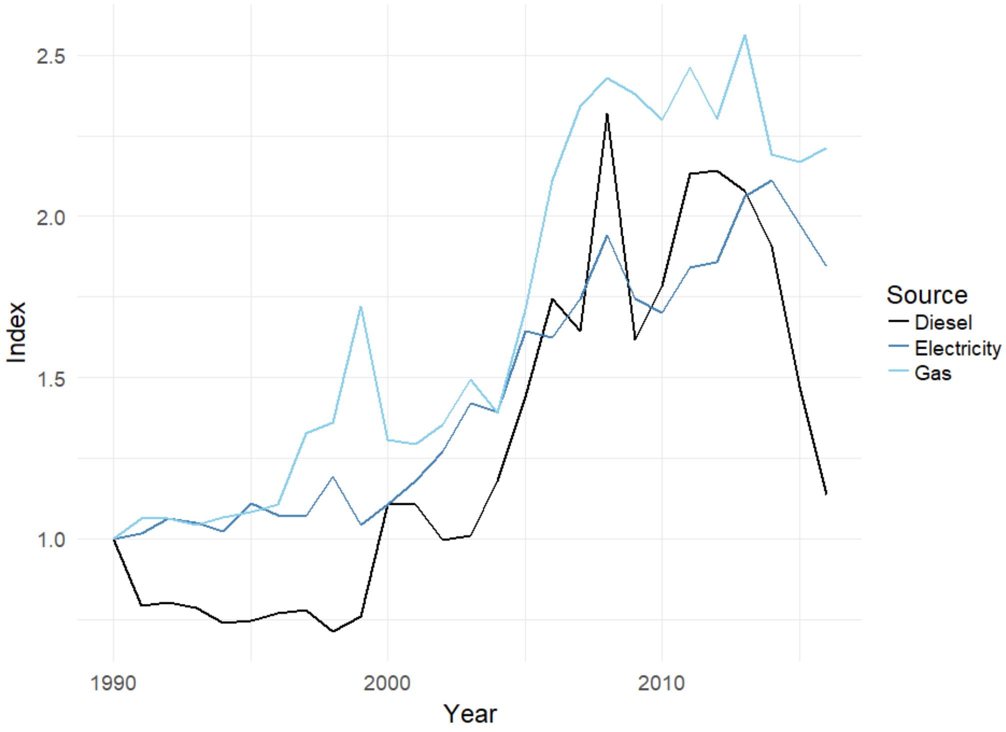
5.1.6. Firms respond to material cost shocks

Firms faced with rising costs – emissions related or not – will respond and try to reduce those costs. This is clear from experience.

In the early-mid 2000s, several major industrial energy users embarked on investments in energy efficiency and energy management programmes. Fonterra, for example, established an energy efficiency strategy in 2003 (still going) to reduce energy intensity by 20% by 2020 and had achieved a 16% reduction by 2016. This was, at least partly, a response to a large energy price shock: between 2000 and 2007, prices for energy rose between 50% and 80% (see Figure 9). This cost shock was also part of a global upswing in commodity prices. This meant that there was not necessarily a profitability shock – because increased output prices partially offset the higher costs. Nonetheless, firms saw this as an opportunity to improve energy efficiency and did.

FIGURE 9: COST SHOCKS HAVE HAPPENED BEFORE

MBIE data on prices by energy source



5.2. No evidence of ETS effects in New Zealand

There is no evidence that the ETS has had impacts on New Zealand firms' competitiveness, in terms of impacts on profits or other measures of average commercial performance at the industry level. Emissions intensive trade exposed industries have experienced growth rates since the implementation of the ETS that are not dissimilar from other firms. This is shown in Figure 10, which charts the distribution of growth in profits[31] by emission intensive and trade exposed (EITE) industries as compared to other industries both before the ETS was introduced, in 2010, and thereafter.[32] This result is replicated across a number of measures of industry performance including investment, employment, emissions and output and labour costs, as depicted in the plots presented below.[33][34]

This analysis is only descriptive. It uses industry level averages and does attempt to account for what might have happened in the absence of the ETS. There would be considerable value in extending this high-level analysis with firm level data – as has been done overseas in evaluations of the impact of the EU ETS. This would enable more definitive analysis. However, one of the difficulties with applying methods used in the EU context is that EU analysis generally includes detailed data on EU country policies and industries and energy prices. Constructing comparable data sets for New Zealand would require compiling novel data sets from primary sources (e.g. on electricity prices) on our major trading partners in Asia.

[31] Industry operating surplus.

[32] Growth rates are calculated for the period from 1987 to 2016, compared to national average growth rates, and divided into pre- and post-2010 periods.

[33] Specifically, national accounts measures of gross fixed capital formation, job counts and compensation of employees.

[34] The results summarised in Figures in this section, showing pre and post ETS densities for outcome measures, are also confirmed by panel econometric analyses (in which we cannot reject the hypothesis that emissions costs do not predict industry activity measures). All of these analyses are, however, limited, in terms of accuracy, by the fact that we have few observations, post ETS introduction, to work from and the analyses typically have very large standard errors due to the fact that industry growth is inherently volatile, year to year. More detailed firm-level analyses would enable better pre and post ETS analysis and more precise estimation of potential effects. This could not be completed in the time available for this analysis.

FIGURE 10: NO PERCEPTIBLE IMPACTS FROM THE ETS ON EITE FIRM PROFITS

Distribution of growth rates. National rate =0. EITE = emissions intensive trade exposed

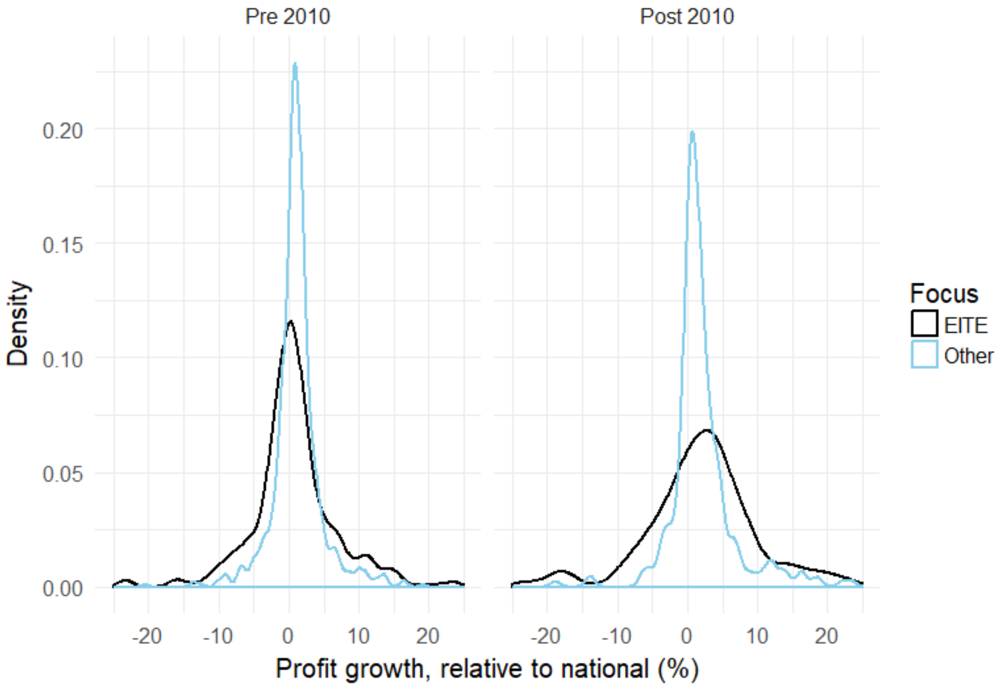


FIGURE 11: NO PERCEPTIBLE IMPACTS FROM THE ETS ON EITE EMPLOYMENT

Distribution of growth rates. National rate =0. EITE = emissions intensive trade exposed

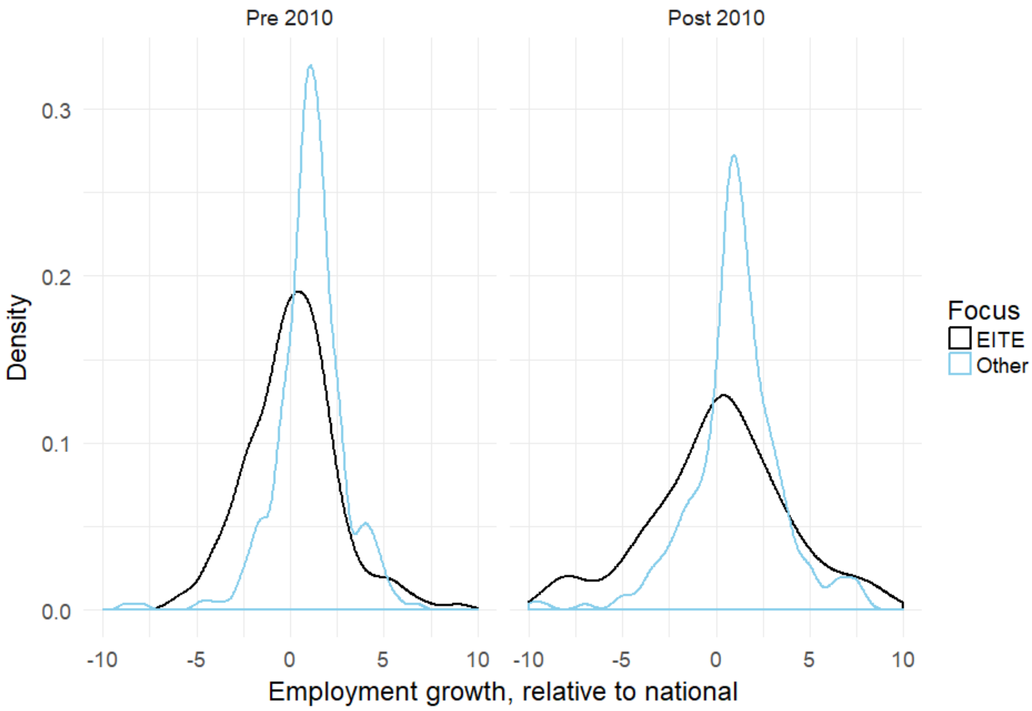


FIGURE 12: LABOUR INCOME HAS, IF ANYTHING, IMPROVED

Distribution of growth rates. National rate =0. EITE = emissions intensive trade exposed

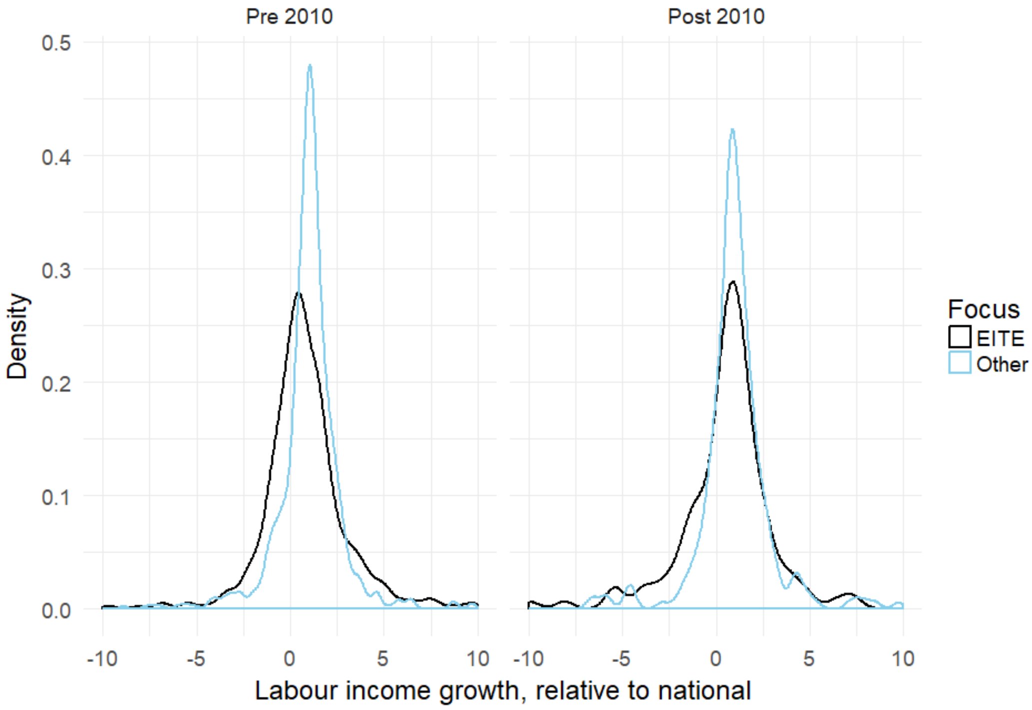
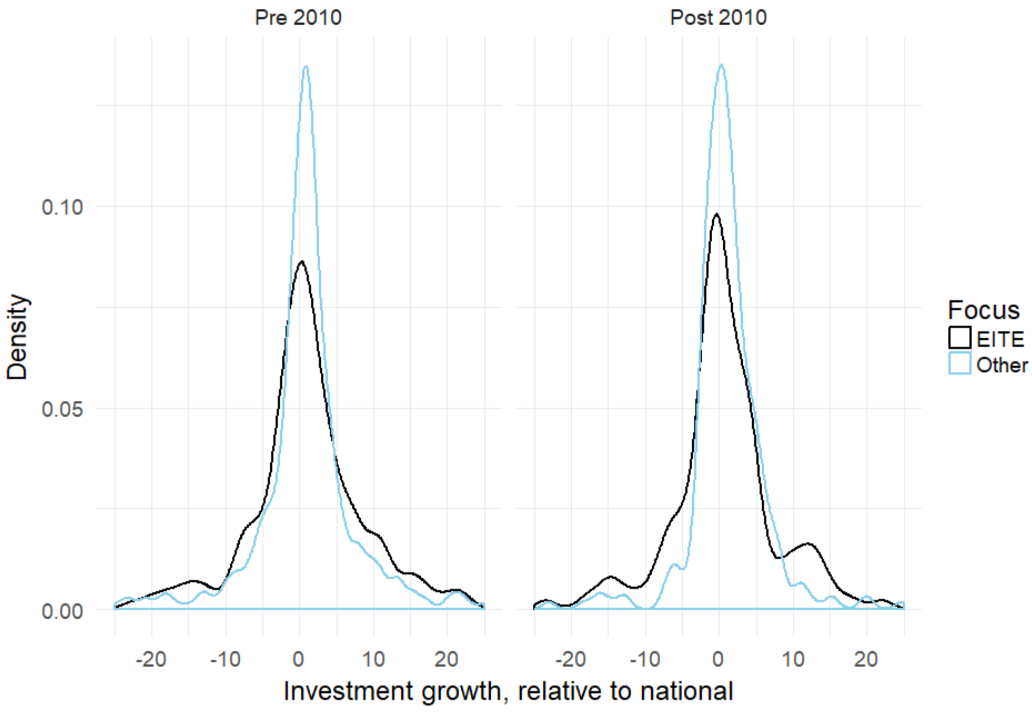


FIGURE 13: NO CHANGE DETECTED IN RATES OF INVESTMENT

Distribution of growth rates. National rate =0. EITE = emissions intensive trade exposed

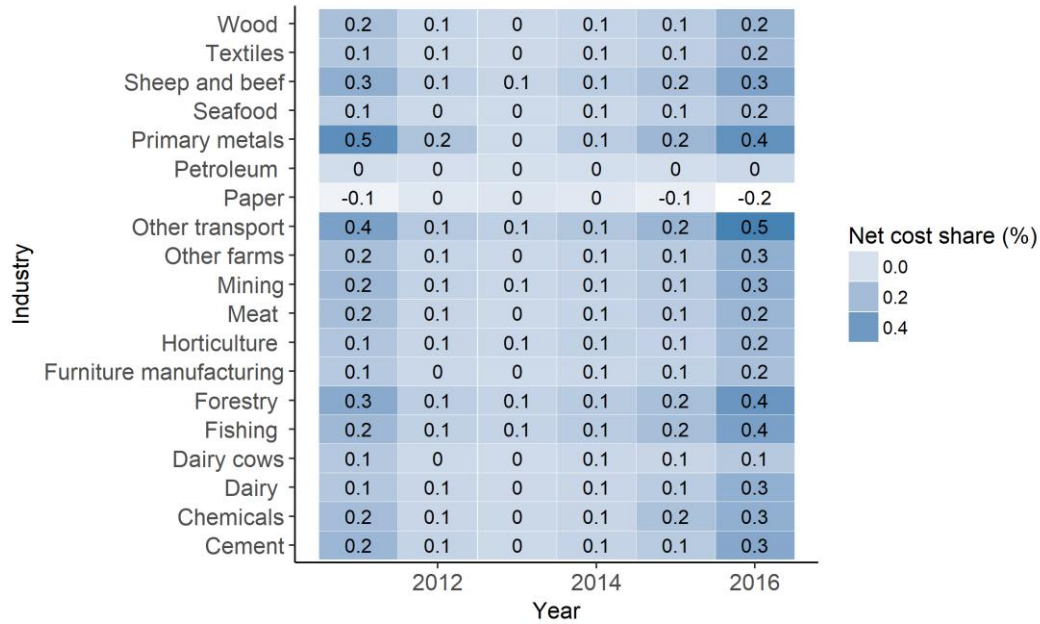


5.3. ETS costs have been minimal at most

Although the analysis above is not definitive, it does accord with what should have been expected given the very small impacts that the ETS has had on firms' costs. Figure 14 shows cost impacts of the ETS, given market prices of New Zealand Units (NZUs) and transition arrangements such as free allocation of NZUs. They show that the largest cost impacts were in the 'Other transport' industry, which is primarily scenic and tourist travel operators who are most affected by transport fuel cost increases and do not receive allocations of free allowances. They also show that ETS costs grew faster than other costs between 2013 and 2016. During that period, producer input prices fell by 0.3% annually across the entire economy and by 2.9% annually in the manufacturing sector. Labour costs rose 1.6% annually. This compares to a more than five-fold increase in the effective market price of NZUs, accounting for two-for-one surrender obligations, from $1.5 per unit to $8 per unit.

The pulp and paper industry is shown to have had a reduction in costs, on average, because of the ETS – due to free allocation of permits to offset costs of electricity. For comparison, Figure 15, below, charts ETS costs as a share of average industry costs without free allocation. This shows the direct incidence of ETS costs, which free allocation is intended to offset. It also illustrates variations in allocations, with some industries receiving few or no allocations of emissions units and others receiving large allocations (such as primary metals).

FIGURE 14: AVERAGE ETS COSTS, WITH FREE ALLOCATION
ETS costs as a share of other intermediate costs (excluding labour costs), reduced to account for the value of emissions permit allocations

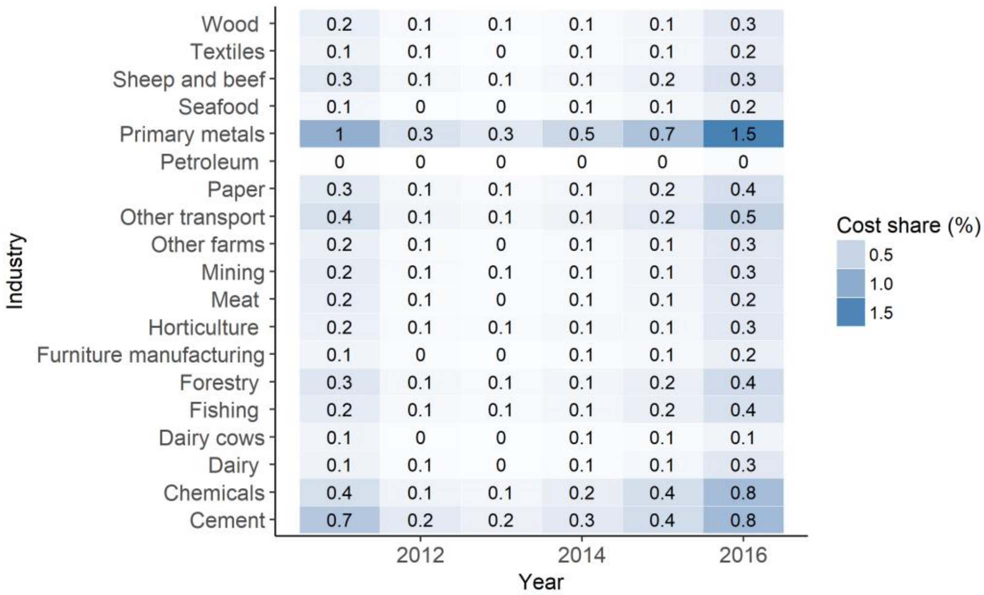


This result may be overstated (costs understated) because the numbers in Figure 14 and Figure 15 do not account for the fact that emissions prices have an influence on electricity prices that is larger than the sector's emissions would suggest. The numbers in Figure 14 reflect total emissions multiplied by NZ ETS NZU prices. Electricity generation in New Zealand is around 80% renewable, but, most of the time, fossil fuel generation sets the price in the market. This is an important feature of the electricity market. It means low cost or low emissions producers are rewarded for being low cost and low emissions. However, it does mean that carbon prices have a larger overall effect on electricity output prices and consumer costs than emissions and emissions prices might suggest, and industry allocations reflect this. Firms receiving free allowances to offset electricity costs typically receive allowances to cover approximately 60% of their electricity consumption, although on average their consumption will be no more than 20% fossil fuel generated.

There are two reasons why these larger electricity cost increases have not been included in Figure 14 and Figure 15.[35] One is that a number of large industrial electricity consumers have interests in electricity generation plants. Thus, if prices have increased, they are likely to have increased the income of these firms, especially where these firms own renewable generation. The paper manufacturer Norske Skogg, for example, owns geothermal generation.[36]

FIGURE 15: AVERAGE COST INCREASE DUE TO ETS, WITHOUT FREE ALLOCATION

ETS costs as a share of other intermediate costs (excluding labour costs)



Even gas-fuelled generation would receive an increase in payments in the relatively few trading hours that oil or diesel-powered generation is setting prices. Indeed, this is why firms sometimes choose to own electricity generation as a 'hedge' against increases in prices. Several major electricity users own their own generation of one kind or another. Usually these are so-called 'cogeneration' plants, which use waste heat to generate electricity. NZ Steel, Carter Holt Harvey and Fonterra are all examples of firms that use cogeneration to manage

[35] A third reason, of less importance, is that estimating these effects is complicated and subject to some debate. Indeed, while most analysts agree with the assumption that electricity prices are larger than emissions would suggest, there are those who disagree.

[36] Norske Skogg did, however, sell part of its geothermal interests in 2016.

energy costs and improve the efficiency of their energy consumption by making use of waste heat. Even though these firms do not always own these assets or operate them.

The other reason for not adjusting electricity costs is that, for much of the time that the ETS has been operating, firms were able to use international emissions units to meet their obligations and these units were often much cheaper than NZUs. Consequently, the NZU price used in these cost estimates is apt to overestimate cost impacts.

5.3.1. Effective carbon prices in NZ have not been high by international standards

Emission prices and energy taxes in New Zealand have not been high by international standards. This can be seen in Figure 16, which plots effective carbon tax rates on industry emissions – including energy taxes and emissions trading scheme prices and carbon taxes.

Effective carbon rates are a better measure of relative cost impacts on firms because they account for the range of costs that firms face that are related to emissions.

That said, most of the countries in Asia Pacific that New Zealand trades with, and that make up a majority of New Zealand's export trade, do have effective carbon rates that are lower than they are in New Zealand: in particular, Australia, Indonesia, China and the United States.

Recent changes to climate policy have also begun to lift New Zealand's effective carbon rates up above what they have been for most of the life of the ETS.[37] This is shown by the dashed lines in Figure 16, which show that New Zealand's effective carbon rates are currently much higher than they were and can be expected to become higher still as the transitional 2-for-1 ETS obligation is phased out (in 2019).

It is perhaps because prices have not been very high that emissions growth rates for New Zealand's most emissions intensive sectors have not differed from those of the economy overall (see Figure 17).

[37] The country effective carbon rates shown in Figure 16 are, on average, for 2012 and the New Zealand value for 2012 is shown for comparability.

FIGURE 16: NZ TRADE VS EFFECTIVE CARBON PRICES

Effective carbon rates for industry. Exports weighted by ETS emissions.

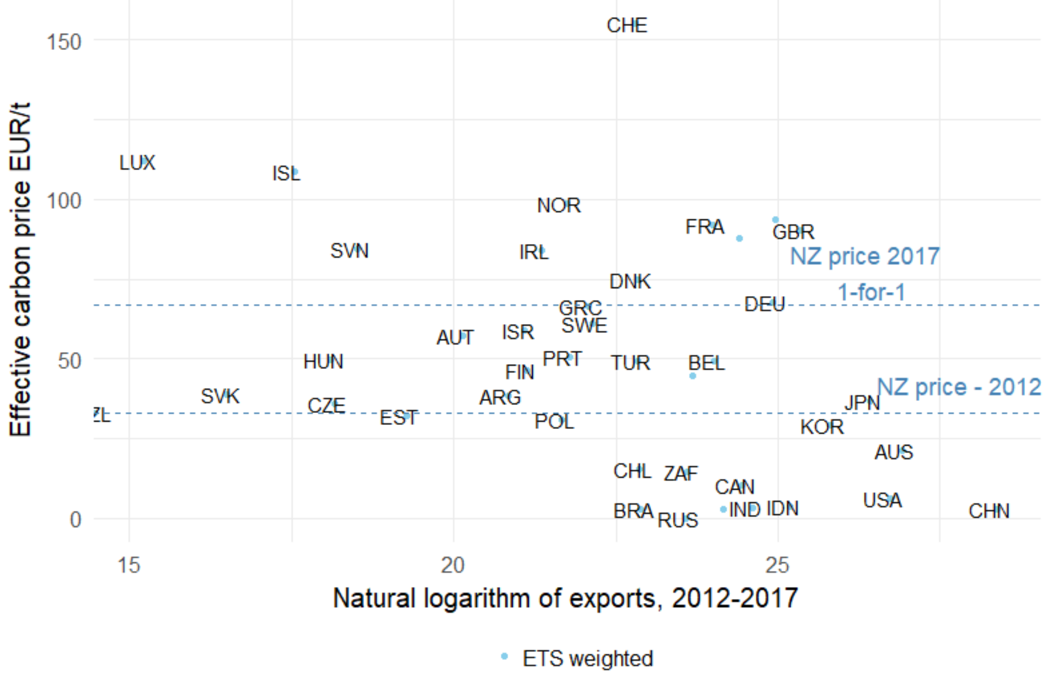
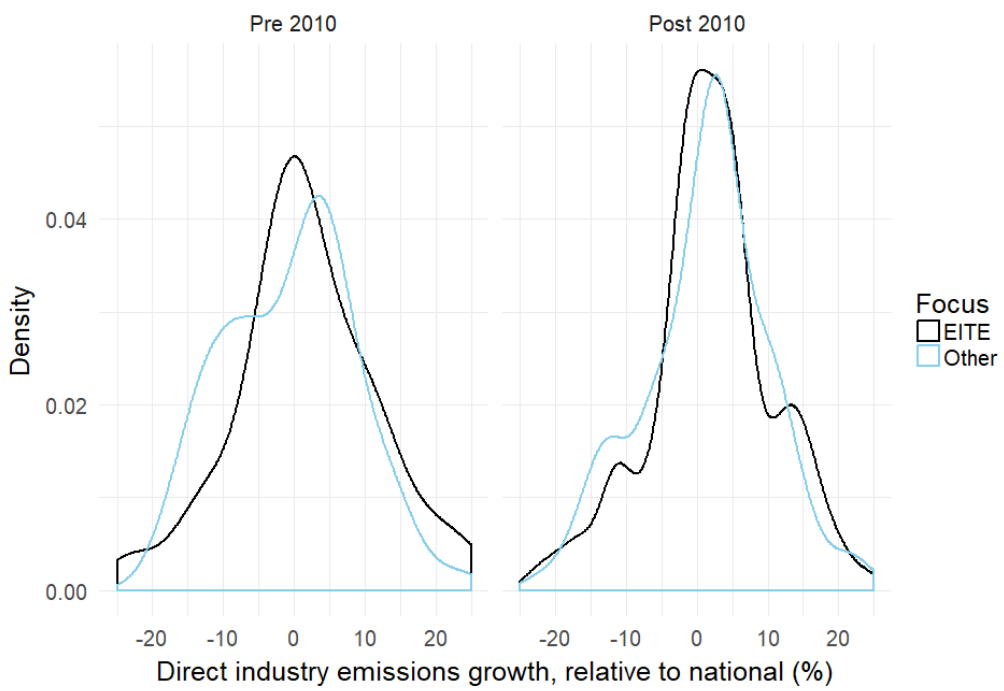


FIGURE 17: EMISSIONS GROWTH BY INDUSTRY GROUPING – NO EVIDENCE OF CHANGES

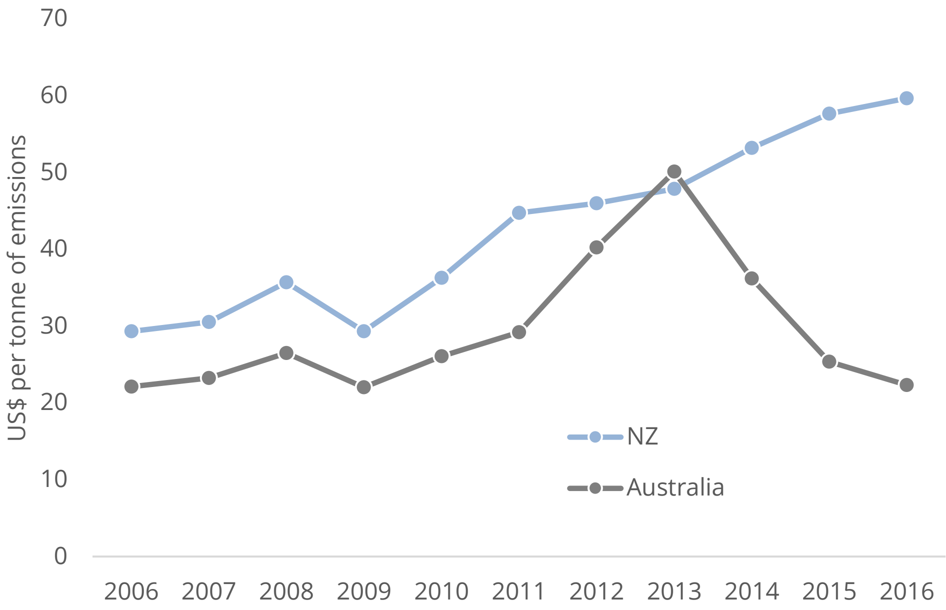


5.4. Trade impacts have been ambiguous

Negative impacts of emissions costs on trade are the key aspect of competitiveness concerns and a key channel for leakage – if not the key channel for New Zealand.

To examine effects of the ETS on trade flows, we made use of the fact that Australia had an explicit price on carbon, affecting mainly energy costs, between 2012 and 2014 (see Figure 18). We analysed the impacts of effective carbon rates on respective trade patterns in New Zealand and Australia, by industry and by export destination and import origin. The objective was to see if divergences in emissions prices predicted changes in trade (see Appendix 2 for details).

FIGURE 18: EFFECTIVE CARBON RATES IN NZ AND AUSTRALIA



In one model, we analysed shares of export markets. This analysis revealed negative effects of climate policy on trade shares (a -0.2% change in market share for a 1% unilateral increase in effective carbon rate). However, this effect is small relative to typical variation in the data. This means we cannot determine if these effects are real or simply a statistical anomaly (a result of randomness and hence statistically insignificant). The result also changes sign if we make small changes to model specification.

A similar analysis was conducted of net imports (rather than trade shares) and for imports and exports separately. The net imports model showed a negative effect of effective carbon rates on net imports (a 1.9% increase in net imports for a 1% increase in effective carbon rates). However, the other two models did not show any statistically significant effects. The presence of mixed results, depending on the model used, leads us to conclude that we have some, but only weak, evidence of a negative effect of effective carbon rates on trade flows.

6. International climate policy developments

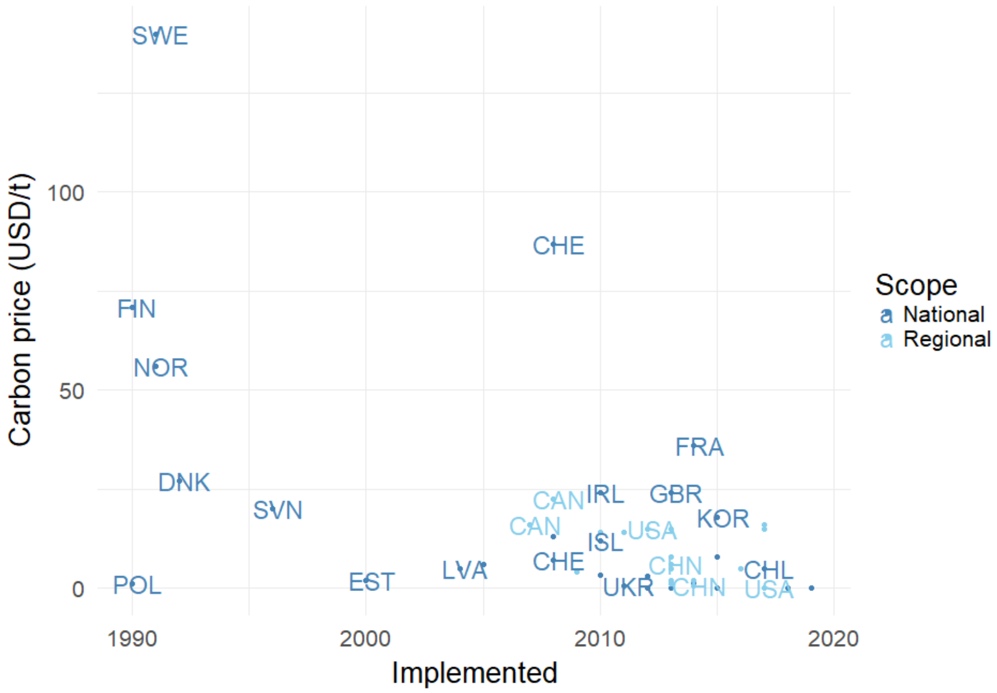
Climate policies implemented by local and central governments around the world have changed significantly in the past decade and will continue to change. In implementing new and increasingly ambitious policies, all countries have an eye on commercial competitiveness of their industries. This creates both an opportunity and a risk for the New Zealand Government. Collaboration with other countries can help to limit differences in firm costs and thereby smooth the path for climate policy. However, countries are also likely to use sector exemptions, subsidies and non-price policies, which can exacerbate competitiveness concerns.

6.1. Current carbon prices and policy

6.1.1. The number of carbon pricing schemes has grown

Carbon pricing initiatives have been developing rapidly (see Figure 19), especially in recent years and since the NZ ETS was introduced. This includes new schemes in emerging economies. While many of these initiatives are regional, several new national schemes are planned for the near future – including implementation of a national scheme in China.

FIGURE 19: EMISSIONS TRADING SCHEMES AND CARBON TAXES IN 2017[38]



[38] Vivid Economics (2017)

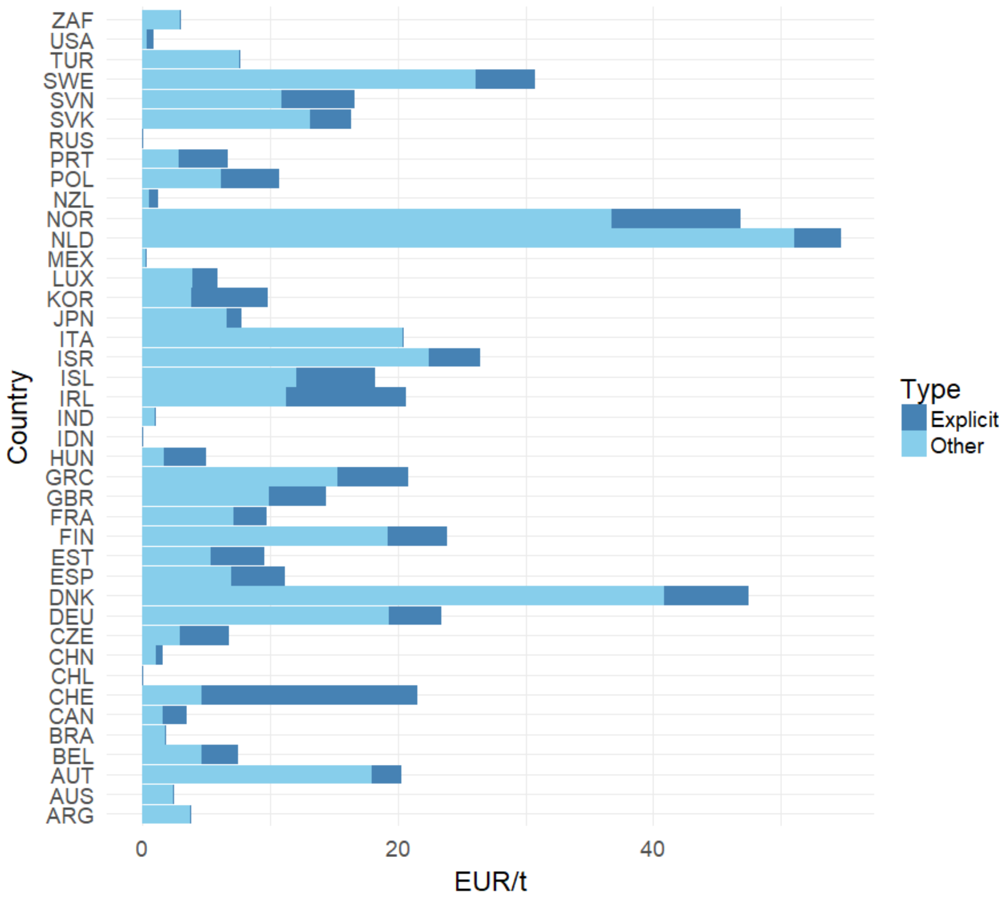
To fully understand the impacts of carbon pricing on competitiveness and on incentives to reduce emissions it is important to account for the impact of energy taxes, as well as explicit carbon prices on firms' costs. Companies do not care much what causes costs to increase. It is the overall price that matters. Furthermore, when analysing potential impacts of changes to policies, the existing tax and cost burden on firms is important context.

The OECD (2016) has developed measures of effective carbon rates that account for a range of prices and taxes. These rates tend to be highest on domestic sectors and particularly on road transport, where rates are high and coverage is broad. However, non-road rates are not trivial, particularly in Europe, as depicted in Figure 20.

Effective carbon rates are low in New Zealand compared to most other countries the OECD. This is partly because of partial exemptions of emissions in the application of the NZ ETS (i.e. two-for-one surrender requirements). The New Zealand values in Figure 20 are also very low because NZUs were very cheap in 2012 ($4 per tonne). When combined with exemptions and converted to Euros (for comparability), New Zealand's effective carbon rate was less than €2 per tonne of CO_2 equivalent emissions.

FIGURE 20: EFFECTIVE CARBON PRICES

Excluding road-related prices, 2012



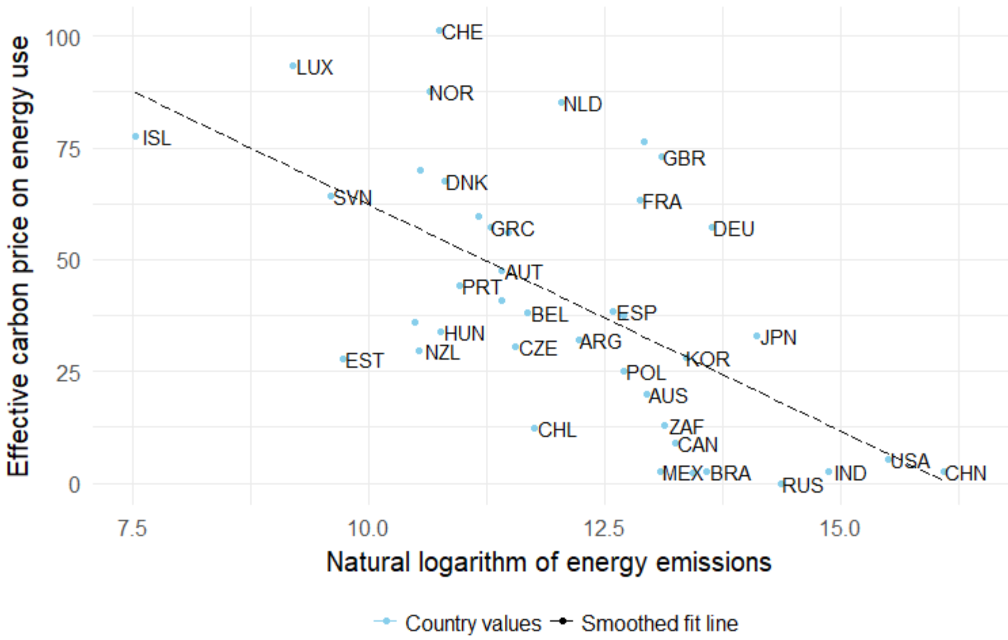
6.1.2. Coverage of effective carbon prices is patchy

While the effective carbon rates in Figure 20 suggest widespread price premia on emissions, they do, however, come with a few important cautionary notes. One is in relation to international coverage, where coverage is poor relative to global emissions intensity because carbon rates are comparatively low in the United States, India and China (see Figure 21). Effective carbon rates in the United States are lower than in South Africa (ZAF) for example.

The other issue is that coverage of effective carbon rates is patchy, sectorally (as shown in Figure 22).

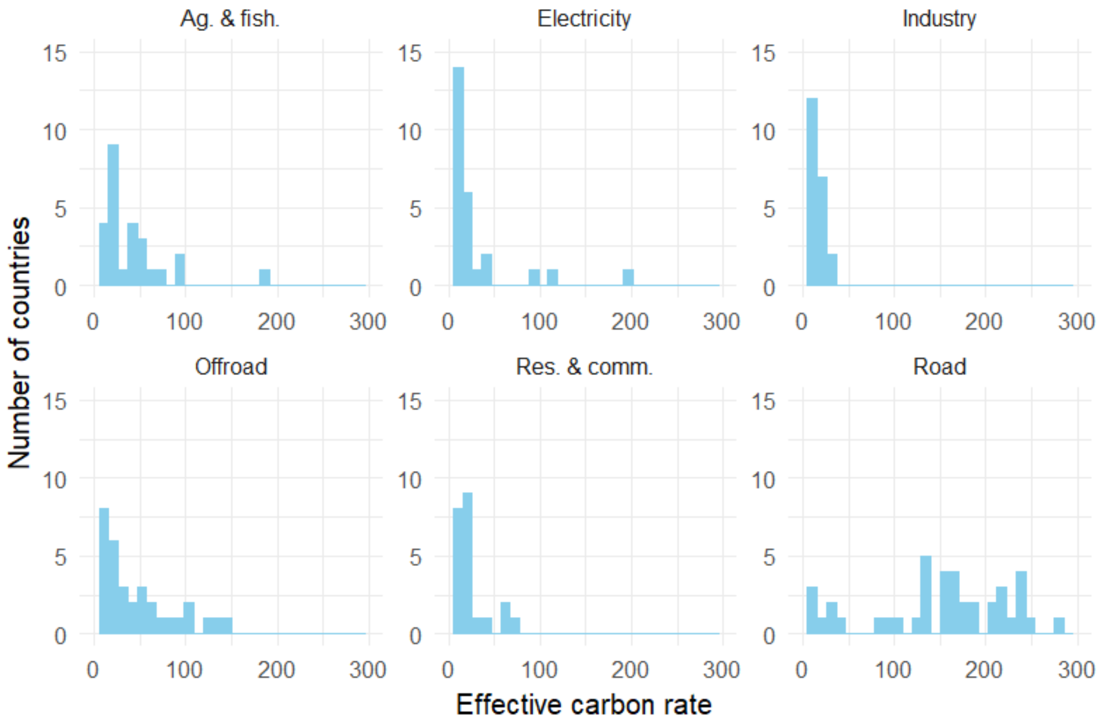
FIGURE 21: EFFECTIVE CARBON RATES AND ENERGY EMISSIONS

USD/t, 2012



Much of this sectoral variation in carbon price coverage appears to be because carbon rates are varied to provide protection to large industries to avoid risks of competitiveness and leakage impacts. The gap between EU ETS prices and domestic carbon taxation, for example, is quite stark – irrespective of (declining) free allocations of permits in the ETS.

FIGURE 22: SECTOR COVERAGE OF EFFECTIVE CARBON RATES



6.1.3. Even in the EU policy is patchy

The EU ETS covers 45% of EU emissions (and also operates in Iceland, Liechtenstein and Norway). The remainder of emissions is either from installations that are too small to be covered (applies to only some sectors)[39] or sectors that are not covered:

- Land use, land use change and forestry (LULUCF, not covered in EU effort sharing)
- Transport
- Buildings
- Agriculture
- Waste.

The EU uses an intra-EU 'effort sharing' process to determine how EU-wide emissions reduction targets are distributed across these remaining sectors. Counties implement their own policies to determine how to meet their effort-sharing targets.

Carbon taxation is widely applied in Europe to complement the ETS and ensure that smaller entities and sectors outside the ETS also face emissions prices (firms in the ETS are typically exempt, although UK has a carbon tax that acts as a price floor for the ETS).

[39] For example, electricity generation is only covered for installations of 20MW or larger.

Of the 28 EU members who levy an explicit carbon tax, the average carbon tax applied is €40/t CO_2e. Rates range from €1/t in Poland to €140/t in Sweden.

In some EU member states, other taxes are applied that are not general carbon taxes but do tax energy use and use of fossil fuels. For example, Germany has electricity and energy taxes on fossil fuels. This tax is added to energy prices in addition to ETS obligations. The tax on electricity is €20/MWh (NZD 36/MWh). However, large users of electricity receive discounts to €6/MWh (NZ 10/MWh) (Flues & Lutz, 2015).[40] Furthermore, firms can receive discounts on other energy taxes, and those energy taxes are set such that coal has the lowest rate in terms of costs per tonne of emissions.[41]

Thus, while emissions pricing and proxies are widely used, they are still patchy even in the EU where there is significant coordination of climate policy. This makes it difficult to compare the impacts of policies on relative industry costs across countries.

Outside the EU, other governments apply similar exemptions. Switzerland has a system of negotiated agreements for offering energy efficiency targets to firms that may face competitiveness issues, in lieu of carbon prices (there is nothing wrong with that, but it does obscure the impacts of policies).

6.1.4. Agricultural emissions are excluded or exempt

The effective carbon rates above are also exclusively prices on energy-related emissions (CO_2). They do not include prices on agricultural emissions. Indeed, the only country outside of New Zealand that has planned to include agricultural emissions in an emissions pricing policy is Kazakhstan. However, that ETS is now on ice.

It is understandable that countries focus polices on CO_2 emissions from energy as these are the distinct majority of emissions in most countries. In OECD countries, agriculture is typically a sector that is politically sensitive and receives subsidies and is more likely to receive grants to support environmental improvement and emissions reductions, rather than see a price on emissions. However, this does pose an issue for New Zealand in terms of introducing polices that seek to incentivise reductions of on-farm emissions.

From a global supply perspective, the absence of constraints on agricultural production’s emissions intensity and production intensity may matter less than constraints, through LULUCF policies, on the expansion of agriculture and deforestation.

Levelling the trade-related playing field for agriculture is complicated by the fact that a large amount of production in agriculture, globally and in less-developed countries, is small in scale, dispersed and not traded. The social consequences of constraining production are potentially large.

[40] Electricity prices in Germany are nearly 90% higher than in NZ, although wholesale prices are not drastically different (€20-€60/MWh). The tax on industry makes up around a third of the price difference between NZ and Germany.

[41] According to Martin et al (2014) the UK Climate Change Levy has a similarly curious lower rate for coal.

This then leads one to the conclusion that it is only reasonable or feasible to mitigate in places where production is at scale and is more efficient than elsewhere.

In most places employing carbon taxes, agriculture and other primary sectors are even subject to exemptions for transport fuel and other energy use such as gas. For example:

- fisheries and greenhouses are exempt from Norway's carbon tax
- diesel use in agriculture is excluded from Sweden's carbon tax (amongst other exemptions)
- Finland provides for reduced rates of electricity tax for greenhouses and reduced rates of excise on diesel (via refunds)
- British Columbia offers exemptions to agriculture and to greenhouse operators
- Ireland applies reduced carbon tax rates for heavy fuel and LPG use for horticulture, and tax relief has been provided since 2012 for farmers for diesel use
- France's carbon tax provides for partial or complete exemption for vulnerable sectors (hauliers and operators of public transport, taxi operators, farmers, fluvial transport of goods, air transport, fishing and navigation shipping)
- agriculture is excluded from the Californian ETS, although the scheme allows for livestock manure management projects as offsets.

6.2. Future policy trajectory

Policy is changing, in no small part because of the Paris Agreement. Actions under the Paris Agreement are also expected to evolve over time through a series of stocktakes and revised pledges. That being so, it is virtually impossible to know how policy will evolve. However, existing NDCs provide an indication of how policy will change in future.

For one, 81 countries have indicated they will use carbon pricing as part of their NDCs. This is important because pricing initiatives can help to limit competitiveness concerns by narrowing gaps between marginal emissions costs faced by producers, at least when compared with other commonly cited initiatives such as renewable energy support.

A majority of countries have also included agriculture and LULUCF in their NDCs (Strohmaier et al, 2016). However, there is no indication that agriculture will be included in any price-based initiatives. Again, this is not strange in any sense.

Increased attention to agricultural emissions is likely

That said, New Zealand may not be unique forever. A number of EU member states will need to start considering agricultural emissions as part of their non-ETS targets (allocated according to the EU's "Effort Sharing Regulation" (ESR)), beyond 2030. For example, in Ireland, agriculture represents 33 per cent of total emissions and is the single largest contributor to Ireland's overall emissions. It is projected to reach 50% of emissions in 2030. This presents the possibility of a developed country (policy) constituency for addressing agricultural emissions with similar – albeit inevitably patchy – mitigation tools as those applied to industry and energy emissions, including emissions pricing (in addition to the current tendency to focus on adaptation and food security concerns).

The New Zealand Government has already established a leadership role in international efforts to research mitigation options in livestock agriculture. The Government was instrumental in the establishment of the Global Research Alliance on Agricultural Greenhouse Gases, which coordinates efforts to control greenhouse gas emissions in agriculture while supporting growth in food production. The Alliance has 49 members and is evidence of ongoing global initiatives to address emissions in agriculture, even if the sector is yet to face the kinds of constraints and costs on emissions faced by the other sectors.

Current NDCs represent widely varying emission constraints and costs

An assessment of potential relative carbon rates, based on NDCs, is set out in Figure 23. This is based on existing sectoral coverage of climate policies and higher direct carbon pricing in world economies as assessed in Vandyck et al (2016).[42] The estimates include comparisons for pledges under the Paris Agreement (NDCs) and an assessment of carbon prices and additional action, consistent with limiting global average temperature increases to 2 degrees.

The Vandyck (2016) analysis incorporates detailed modelling of energy systems and can account for mitigation actions in NDCs that are not price-related (such as renewable energy targets).

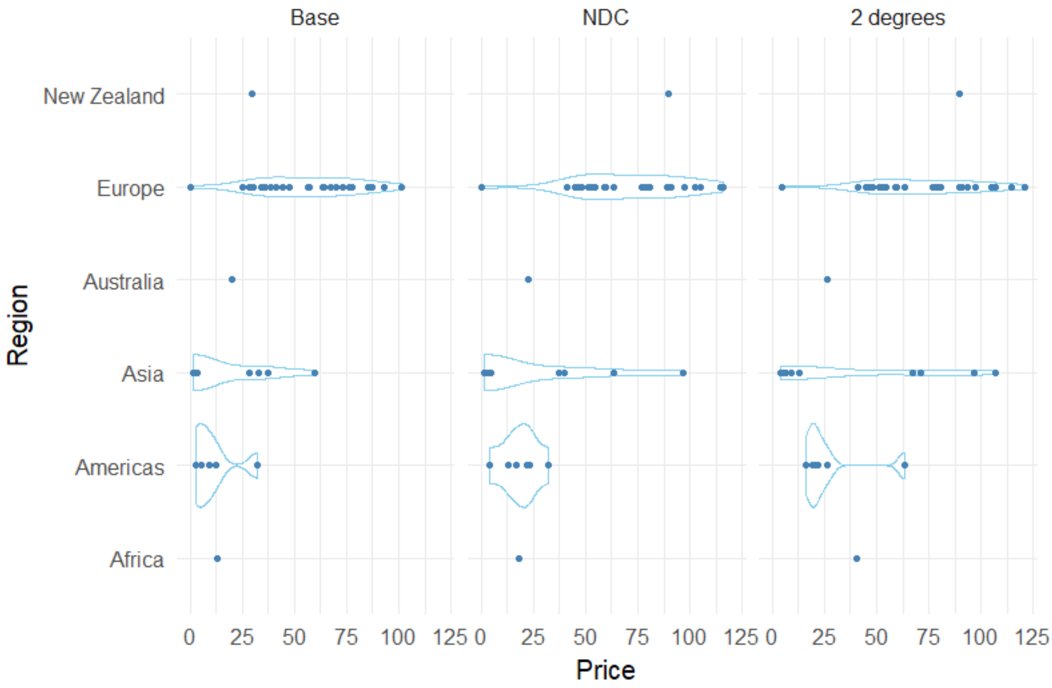
The key messages for New Zealand Government are:

- NDCs, if implemented, imply widespread increases in effective carbon rates by 2030
- Under its existing NDC, New Zealand's effective carbon rates are expected to be much higher than in Australia and most of our key trading partners in Asia (though not everywhere)

[42] It would also be reasonable to presume some expansion of coverage of climate policies, but that is not certain to happen. Most countries with explicit prices on carbon have a longstanding preference for providing assistance to particular sectors – whether for reasons of industrial policy or because of concerns about competitiveness effects. Agricultural is an extreme case.

FIGURE 23: ESTIMATES OF FUTURE EFFECTIVE CARBON RATES, BY COUNTRY

Based on changes to carbon costs estimated by Vandyck et al (2016). US dollar prices in 2030. Dots show country average carbon prices and lines highlight distributions of prices by region.



The analysis used to calculate effective carbon rates in Figure 23 indicated that New Zealand's pledge to reduce emissions by 30% in 2030, compared to 2005 levels, is associated with a carbon price that is:

- more than 5 times the global average
- twice that of the average carbon price expected in the EU and
- more than three times the carbon price in Australia.

Importantly, New Zealand is not an outlier. The emissions price predicted for New Zealand is only in the top half of the price range produced by Vandyck et al (2016) for a 2 degrees target. It is within the bounds of global average carbon prices in 2030 that are consistent with achieving the objectives of the Paris Agreement. The High-level Commission on Carbon Prices (2017) puts this at a range between US$50 and US$100 per tonne in 2030.

New Zealand emission prices are at the upper end of the distribution of the prices, and this result is unsurprising. It repeats a result that is consistently found in international comparisons and analyses of mitigation costs. Mitigation in New Zealand is comparatively expensive.[43]

However, it is not a fait accompli; rather, it is an indication of what might happen and perhaps a cautionary note that climate policy needs to include an adjustment mechanism or monitoring process to ensure that carbon prices do not grow significantly out of step with developments elsewhere in the world and amongst major trading partners.

The result that New Zealand is assessed to have relatively high emissions prices is most likely because of the well-known problem of New Zealand's emissions profile and the relative paucity of known and lower cost mitigation options for agricultural emissions. On the other hand, and perhaps more to the point, it reflects the fact that mitigation in the energy sector for most other countries is an easier task than for other sectors, because that is where globally, in contrast to New Zealand, the lion's share of emissions resides and, thus, where the lion's share of research is targeted.

Comparatively few options for low cost mitigation means that, to meet New Zealand's targets, trade exposed sectors in New Zealand will have to either abate more emissions than their rivals overseas, at a consequently higher cost than their rivals, or else pay a higher price for their emissions than overseas rivals. If the cost differential is large enough, this could create significant losses of competitiveness and potential for leakage.

The analytical results in Figure 23 also exclude the possibility of international trade in emissions permits or emissions offsets. If this sort of trade were to occur, it would cause emissions prices to equalise across countries. This would reduce any direct impacts on firm competitiveness from otherwise high emissions prices. However, this trade is by no means costless. In New Zealand's case, it would mean an increase in imports or, equivalently, an increase in overseas borrowing. That is, linkages between countries can improve the cost-effectiveness of mitigation and reduce mitigation costs, but they do not fully offset the costs that countries face in having to meet their mitigation targets or commitments.

[43] Importantly, the completion of this report precedes completion of related New Zealand specific analyses, by other researchers, of the economy-wide costs and cost-effectiveness of emissions reduction targets and policies (NZIER CGE analyses and partial equilibrium modelling of emission reduction pathways by Vivid Economics, Motu Economic and Public Policy Research and Concept Consulting). Some of the findings in this report may need to be revisited and modified in light of the results of these analyses.

7. Potential future effects

An evaluation of the potential impacts of climate policy on New Zealand firms is complicated by the evolving nature of international climate policy. Likewise, prospective assessments seem to have a habit of being more extreme – in terms of negative impacts on firms – than ex-post assessments suggest occurring.

Nonetheless, it is still useful to analyse potential costs on firms of increased carbon prices, not least because we can learn something from testing the relative impacts of increased effective carbon rates on different industries and in markets.

To do this requires some indication of prices. For that purpose, we use indicative ranges of potential prices and reference the numbers presented in the previous section from the analysis of Vandyck et al (2016). This does not mean these are the only possible futures or even a single possible future. They are a basis for illustrative analysis.

To be clear, the indications from the modelling presented in the previous section are that increasing the ambition of New Zealand's current emissions target would shift the relative costs of carbon (effective carbon rates) in New Zealand well beyond that of most other countries, particularly New Zealand's major trading partners. So, the impacts that are assessed might be presumed to be large. However, this is not always so, and that insight alone is quite useful.

The analysis in this section considers both changes to relative effective carbon prices and the effects of extending the scope of policy (the ETS) to put a price on on-farm emissions. In doing so, we ignore any practical issues associated with doing this.

We also analyse impacts under both the NDC and 2 degrees scenarios depicted in Figure 23. Interestingly, New Zealand's relative effective carbon rates are smaller under the higher ambition 2 degrees scenario, because higher ambition requires increased action, as well as higher effective carbon rates amongst major emitters that are amongst New Zealand's major trading partners. This underscores that the impacts of climate policy on New Zealand's emission intensive and trade exposed sectors will depend significantly on global policy developments.

To analyse impacts on firms, we use existing industry revenue and profitability information (National Accounts data) and simply analyse cost impacts directly. We also consider the effects of reductions in sector emissions intensity, accounting for changes in supplier as well as direct emissions intensity (although these adjustments make minimal difference to the overall assessment).

Using existing industry performance avoids the considerable complexity and false precision that would be needed for analysing trade effects, which would require comparable analysis of competitors in other markets.

7.1. A few sectors would find higher carbon prices very challenging

Whether policy changes impact negatively on firms' competitiveness will depend significantly on their emissions intensity. Some sectors can, on the face of it, bear quite large changes in carbon prices. Figure 24 shows that emissions costs are small enough that even quite high carbon prices (such as NZ$200 per tonne of CO_2e) do not seriously endanger firm profitability (the left axis) in some industries (based on analysis which ignores innovation and adaptation).

However, some sectors would become unprofitable at small emissions prices. The primary metals sector stands out as being highly sensitive to carbon costs.

By way of illustration, the NDC analysis in the previous section equates to an effective carbon rate of $NZ183 per tonne of CO_2e – in both an NDC and a 2 degrees scenario. However, the overall impact on industry costs depends on the scope of application of that price and whether it is faced by industries and their suppliers. Weighted average effective carbon rates across New Zealand are:

- $41/t CO2e under current ETS prices and taxes
- $49/t CO2e under current ETS prices and taxes once the 2-for-1 surrender obligation is removed from the ETS
- $116/t CO_2e under New Zealand's current NDC (-30% by 2030 compared to 2005) with the current ETS scope
- $183/t CO_2e under New Zealand's current NDC (-30% by 2030 compared to 2005) with the ETS expanded to cover agriculture.

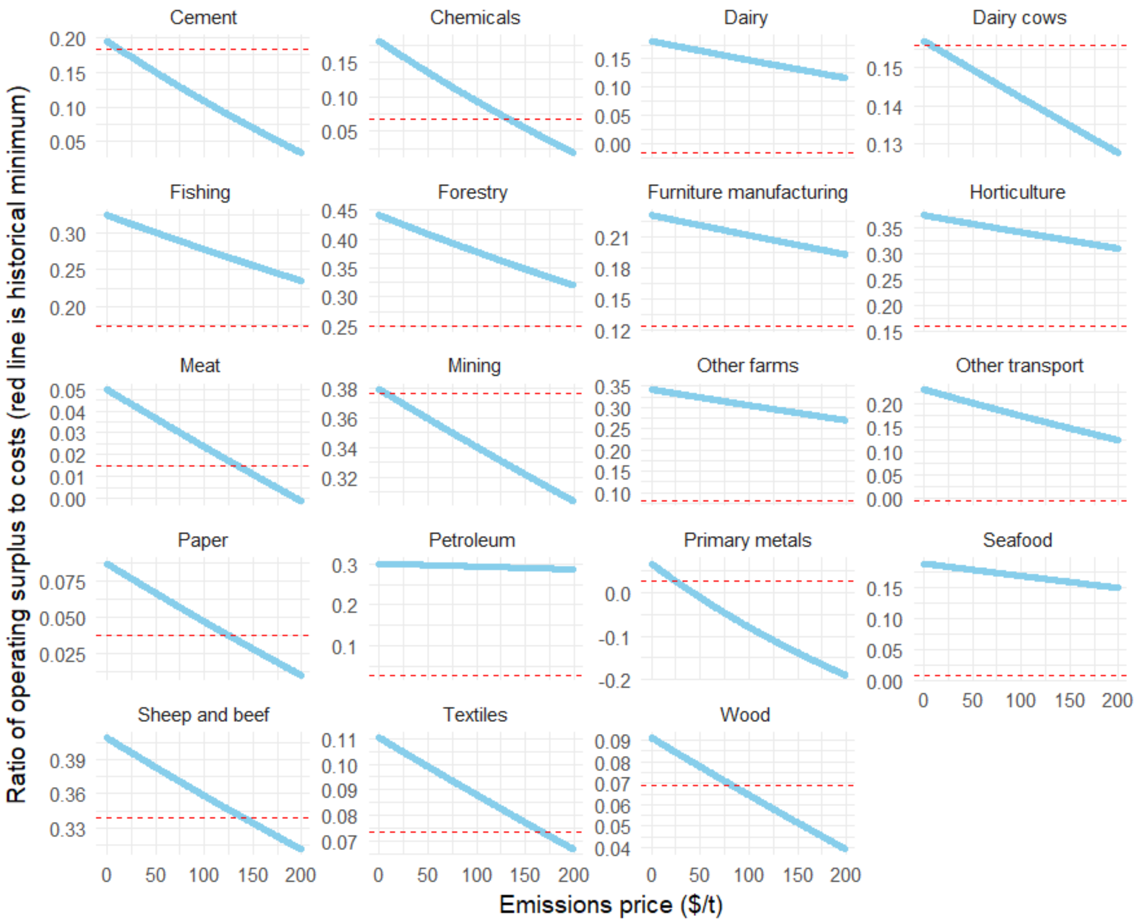
The high end of those scenarios corresponds roughly with the far right of the prices presented in Figure 24. So, the average firm in most industries could, on the face of it, absorb these costs with reduced profitability.[44] Of course, they would not need to 'absorb' all these costs, as other countries will have rising carbon costs and international prices for exported products will rise to reflect these higher costs. This illustration assumes away any response to higher costs, which the review in section 8 highlights as a potentially important factor.

However, some sectors would become unprofitable at small emissions prices. The primary metals sector stands out as being highly sensitive to carbon costs.

[44] Note that these results do not account for firms' debt obligations, which can vary widely and can significantly affect ongoing profitability and the ability of the firm to fund investment.

FIGURE 24: IMPACTS OF CARBON PRICES ON FIRM PROFITS, CURRENT ETS SCOPE

Blue line is profit-to-cost ratio as carbon price varies. Carbon prices reflect NZU prices, rather than effective carbon rates. Red line is minimum historical value.[45]

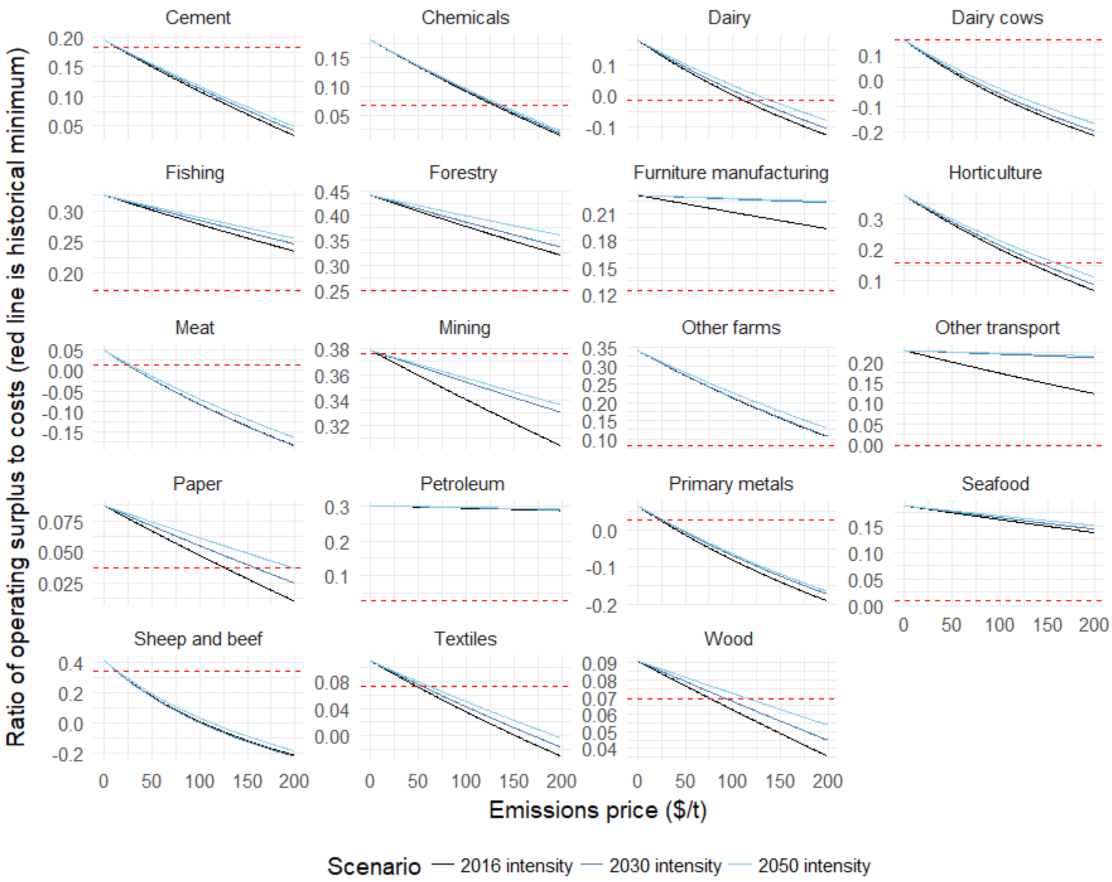


7.2. Expected changes to emissions intensity make little difference

Accounting for expected improvements does not change the assessed impacts on industries too much, except in cases where industry costs are primarily due to transport costs and electricity costs. For other industries – those with process emissions and emissions in forms of energy other than electricity – the effects of emissions prices are much as they were without adjustments for energy intensities.

[45] This presentation is based on industry profitability according to national accounts data for 2016. This was a year of poor profitability for a few sectors, which is why the red line intersects the maximum value for profitability for that sector, as in the case of Dairy Cow farming.

FIGURE 25: DIRECT IMPACTS OF CARBON PRICES ON FIRM PROFITS, WITH ADAPTATION AND CURRENT ETS SCOPE



The basis for the gains in emissions intensity shown in Figure 25 are summarised in Table 4, below. These are "business as usual improvements" but in some cases do reflect an explicit assessment of the effects of carbon prices on emissions intensity. This is the case for electricity assumptions and the road transport assumptions. However, the prices in those analyses are small relative to the kinds of prices implied by the analysis presented in the previous section.

TABLE 4: ASSUMED EMISSIONS INTENSITY IMPROVEMENTS

	Annual rate	Basis for assumption
Other primary	0%	Past trend for agricultural sector
Dairy	-1%	MPI, farm productivity
Sheep	-1%	MPI, farm productivity
Industry	-1%	EECA
Primary Metals	0%	Neutrality, no data
Commercial	-1%	EECA
Electricity	-6%	MBIE, mixed renewables scenario
Road	-2%	Ministry of Transport
Mining	0%	Neutrality, no data

7.3. Livestock agriculture would struggle with costs of on-farm emissions

For livestock agriculture and food processing sectors, impacts on profitability will depend significantly on whether or not the current scope of the ETS is extended to include agriculture. As shown in Table 5, the profitability of the meat and dairy manufacturing industries is much more sensitive to carbon prices if on-farm methane emissions are subject to pricing in future. Again, these results assume no innovation response on the part of firms and farmers.

The results in Table 5 are based on typical profitability historically as measured by operating surpluses. They exclude any normal return on capital. As such, an expectation of increased emissions prices would cause firms to respond and adjust or to close long before these break-even prices are breached.

The analysis, which is summarised in Table 5, is based on median profitability of industries and firms over the past 30 years. However, in the case of firm-specific analyses, the data is generally more limited with profitability estimates based on 2-10 years' worth of data.

The analysis also accounts for expected reductions in emissions intensity between now and 2030, based on trends forecast by government agencies.

Notably, for the firm-specific analyses, the carbon price is not the key determinant of commercial viability. The profitability of each of these firms is affected by international commodity prices for key inputs and for their outputs. All are affected by international competition and by exchange rates which can undermine their profitability.

In terms of input costs, the profitability of Methanol and Urea production is more dependent on gas prices and product output prices than on emissions prices. Aluminium smelting relies on cheap electricity and currently faces more short-term risk (arithmetically) to continued operation from transmission prices and international aluminium prices than from emissions prices. Similarly, the profitability of steel production at Glenbrook is sensitive to transmission prices, to gas prices and to international iron ore prices and producer margins as between iron ore prices and raw steel prices.

All of the firms shown in Table 5 have an uncertain long-term future – in terms of breaking even and earning a profit – irrespective of climate policy. Although this is not to say that climate policy should necessarily presume that the future of these firms is known one way or the other particularly as plant closure could be environmentally inefficient in terms of causing leakage.

TABLE 5: SENSITIVITY OF FIRM PROFITS TO CARBON PRICES: BREAK-EVEN PRICES

	Break-even carbon price ($/tCO2e), 2030	
	Current ETS scope	**ETS - all gasses**
Dairy product manufacturing	240	40
Meat and meat product manufacturing	240	40
Aluminium - NZ Aluminium Smelters	50	50
Steel - Glenbrook	50	50
Methanol - Methanex	60	60
Primary metal and metal product manufacturing	100	100
Urea manufacturing - Ballance	110	110
Cement - Golden Bay	110	110
Textile and leather manufacturing	786	180
Basic chemical and basic polymer manufacturing	230	230
Horticulture and fruit growing	1,500	230
Non-metallic mineral product manufacturing	320	320
Pulp, paper and converted paper product manufacturing	540	540
Wood product manufacturing	590	550
Fishing and aquaculture	760	760
Seafood processing	1,050	780
Forestry and logging	910	910
Petroleum and coal product manufacturing	2,810	2,810
Coal mining	3,730	3,730
Other manufacturing	5,620	5,620

7.4. Similar markets effects due to Asia-Pacific focus

To determine if market differences – and different relative effective carbon rates – would affect impacts on industry profitability, effective carbon rates (ECRs) have been compared between different markets on a trade-weighted basis. The results are shown below. An ECR ratio less than 1 indicates that industry faces effective carbon rates that are higher than those in its export markets on a trade weighted basis.

The results in Table 6 show that the changes in relative carbon rates are reasonably similar for all industries. This reflects relative similarity of export markets. The one exception is forestry, because of the large amount of trade with Korea (second largest market for forestry exports) which is assessed as having a higher carbon price than New Zealand as part of its NDC. All industries will see a relative deterioration in competitiveness, assuming no firm response.

TABLE 6: RELATIVE EFFECTIVE TRADE-WEIGHTED CARBON RATES

Exports, ratios of NZ ECR to trade-weighted export destination ECR

Industry	**Current ECR, ratio**	**NDC ECR, ratio**	**Change**
Chemicals	0.49	0.24	-0.51
Coal mining	0.26	0.11	-0.58
Dairy manufacturing	0.22	0.12	-0.46
Farming	0.50	0.23	-0.54
Fertiliser	0.49	0.20	-0.59
Fishing	0.47	0.23	-0.51
Forestry	0.20	0.18	-0.12
Horticulture	0.58	0.28	-0.52
Meat manufacturing	0.67	0.35	-0.48
Non-metallic mineral manufacturing	0.57	0.26	-0.54
Other manufacturing	0.54	0.25	-0.54
Petroleum	0.33	0.13	-0.60
Primary metals	0.68	0.31	-0.54
Pulp and paper	0.34	0.19	-0.43
Quarrying	0.32	0.15	-0.53
Seafood processing	0.42	0.22	-0.48
Textiles	0.86	0.39	-0.55
Wood manufacturing	0.43	0.21	-0.51
Total	0.41	0.21	-0.48

7.5. Leakage is a risk in some sectors

The biggest risks of leakage are in:

- steel
- cement
- aluminium
- petrochemicals – specifically methanol and urea production.

Sectors that are consistently singled out as being at risk of leakage in jurisdictions such as the EU (see Reinaud (2008) and Droege (2009)).

But leakage is, in all cases, not certain. Even if policy becomes much more stringent in New Zealand than elsewhere.

Rates of leakage will depend on both the emissions intensity of activities that are displaced and the emissions activities that displace them. This means that there is considerable variation in potential leakage rates.

An illustration of this is provided in Table 7. In all cases, global emissions could decline if New Zealand production is displaced. This is in the 'Low' leakage rate row in Table 7. In the case of Aluminium, this would require New Zealand production being displaced by production from global best practice plant in a country with very low emissions intensity of electricity, such as Norway. This seems unlikely given the amount of aluminium produced in Asia-Pacific region. Most likely leakage rates would be large.

Here the rate of leakage is shown for small changes in output. For example, a $1000 reduction in Aluminium production, in 2016 prices, causes a 3,230 kg increase in emissions, the 'Mid-level' example.

TABLE 7: EXAMPLES OF RANGES IN POTENTIAL INDUSTRY LEAKAGE RATES

Industry	Aluminium	Meat	Steel	Cement	Dairy
Marginal leakage rates, annual change in global emissions (kg) per reduction in output ($000s)					
Electricity only	1,175	6	103	111	4
All emissions:					
Low	-492	-583	-426	-622	-193
Mid-level	3,230	29	70	361	75
High	3,628	678	537	534	302
Industry Context[46]					
Output ($m)	876	10,911	967	299	16,616
Value-added ($m)	264	2,000	353	87	4,240
Operating surplus ($m)	24	496	92	68	2,501
Exports ($m)[47]	876	7,525	280	12	14,078
Competing imports ($m)	53	142	158	13	1,059
Average emissions intensity (kg/$000s)	1,226	1,428	1,412	2,121	1,395

If leakage is to occur from the Aluminium sector it is most likely that it would be because the Tiwai smelter closes – rather than from small changes. On these mid-level leakage rates, this could cause 2.8 million tonnes of additional emissions, globally, per annum.

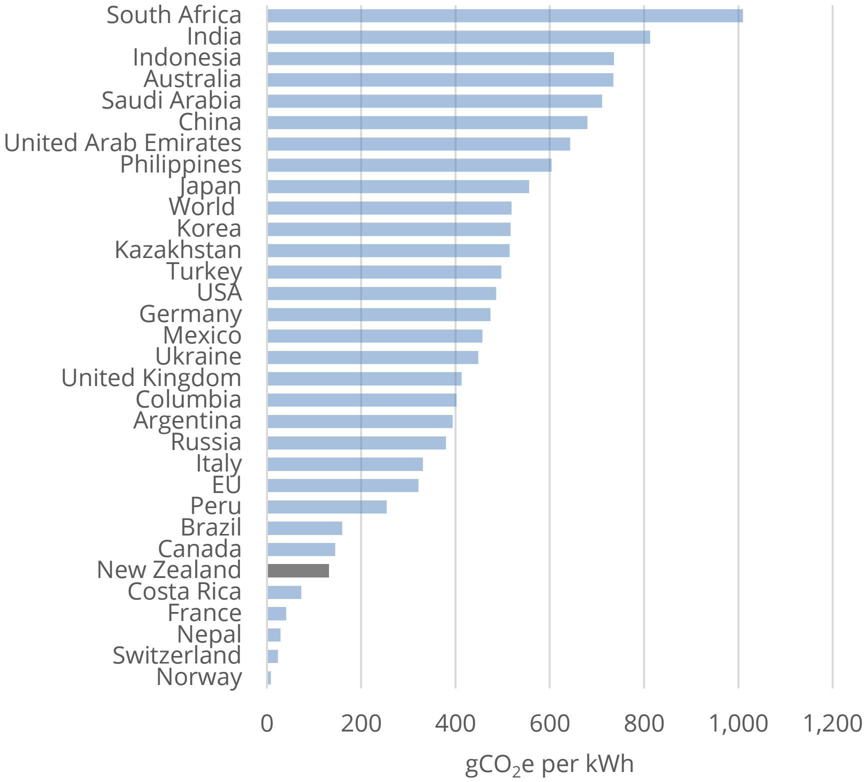
Importantly, this sort of change in emissions can only be considered leakage rate if aluminium production would have remained in New Zealand without differences in climate policy.

A key reason for significant leakage risk in the aluminium sector is the low emissions intensity of New Zealand's electricity sector (see Figure 26Figure 2) and the fact that aluminium production is electricity intensive.

[46] Output, value added, and operating surplus values are estimates for Aluminium, Steel, and Cement.
[47] Export values are based on matching exported products to industries. The totals differ from purely product-based classifications in normal export statistics.

Indeed, the low level of emissions in New Zealand electricity production means that there is a widespread risk of leakage, in moderate amounts, from industry activity being displaced if emissions prices in New Zealand become significantly higher than in other countries.

FIGURE 26: ELECTRICITY SECTOR EMISSIONS INTENSITY BY COUNTRY
2014



In steel and cement, production technologies and practices play a much more important role, than electricity, in determining emissions intensity. And New Zealand cement and steel production use technologies that are relatively 'average' by global standards, in term of emission intensity.[48]However, low emission electricity still plays an important role in causing positive mid-level leakage rates. If New Zealand starts to import more steel and cement[49] it is most likely to be sourced from countries such as Australia or Indonesia – based on historical import trends – and both countries have average emissions intensity in electricity which is 5-6 times more emissions intensive than New Zealand.

Table 7 also highlights that there is potential for positive emissions leakage in the dairy sector – and potentially in the sheep and beef sector – as discussed below.

[48] Although they are improving with, for example, Fletcher Building's Golden Bay cement currently undertaking a project, supported by government, to reduce emissions from coal use by substituting some coal for waste tyres.
[49] Or clinker, used to produce cement.

Agriculture

Leakage risk in agriculture relates is more subtle than in some other sectors. A good deal of any cost impacts from climate policy can be expected to be absorbed by the cost of land – with costs borne by current owners who will face a reduction in asset value. Land may also move out of more emissions-intensive livestock production and into other forms of production such as horticulture or forestry.

The key channels for leakage in agriculture will be reduced investment in production capacity, causing a reduction in growth of supply from New Zealand which is displaced by production elsewhere which may be more emissions intensive. Or a switch in land use away from livestock production with New Zealand production displaced by production from elsewhere and which may be more emissions intensive.

Producers may, of course, investigate mitigation opportunities or ways to differentiate products to enable them to pass costs through to buyers in export markets. However, Woods and Coleman (2012) note that agricultural exporters do not appear to have been able to use product market differentiation to avoid negative impacts of cost shocks on profitability in the past.

In principle, a price on emissions incentivises research and the uptake of more productive and less emission intensive farm management practices and drives poor performers out of the industry. On the other hand, when profits fall due to increased costs, farmers are apt to seek more off-farm income. This reflects a disinvestment of time, amongst other things, and is unlikely to be associated with increased innovation in farm management practices (Fairweather et al, 2007).

As for other sectors, a key element in determining leakage risk is whether, if New Zealand production declines or grows more slowly, production is displaced by more emissions intensive production. This is quite possible but is not guaranteed.

Estimates of emissions intensity in livestock production suggest that intensities vary widely internationally, as illustrated in Figure 27. However, as shown in Table 8, there is a negative correlation between emissions intensity and export trade. Countries with a comparative advantage in livestock production (revealed by large shares of export trade) tend to have emissions intensities which are relatively low, such as in the case of dairy production in North America and the EU.

FIGURE 27: VARIATION IN EMISSIONS INTENSITY OF RUMINANT LIVESTOCK PRODUCTS

Opio et al (2013). Variation includes different climates and different ruminant species

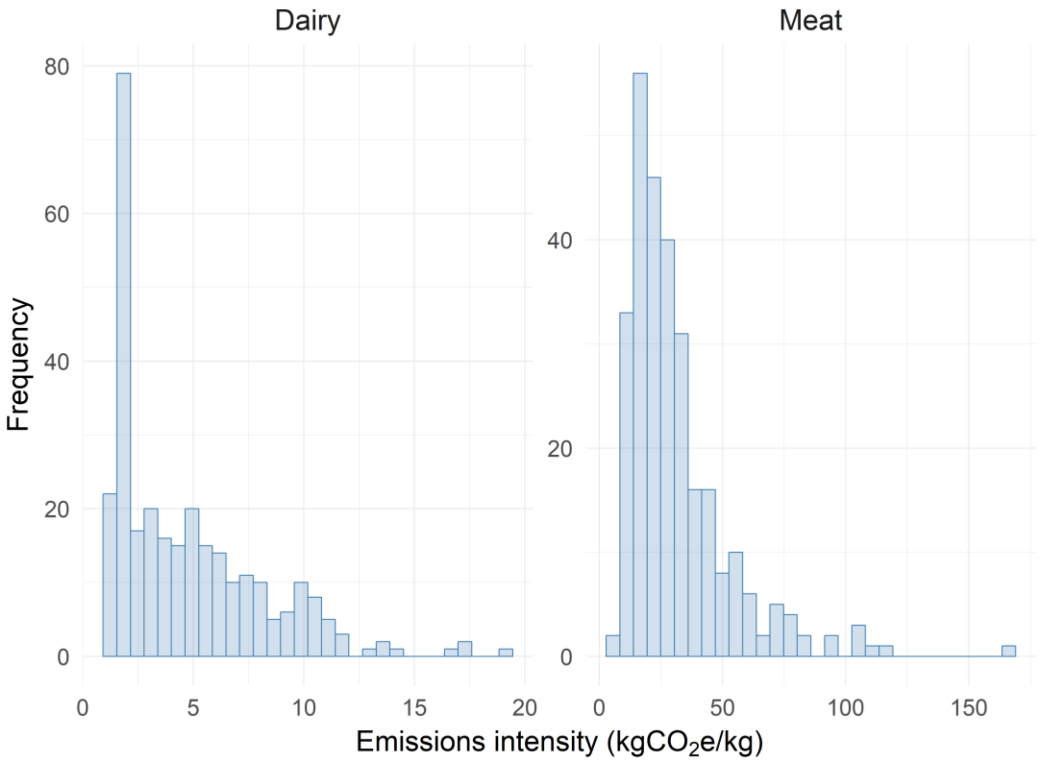


TABLE 8: GLOBAL TRADE SHARES IN NZ LIVESTOCK PRODUCTS AND EMISSIONS INTENITIES

Opio et al (2013), UN COMTRADE exports for NZ export products, average 2012-2016

	World export shares (ex NZ)		**Average emissions intensities**		
Region	Dairy	Meat	Dairy	Beef	Sheep and goats
East and South East Asia	11%	8%	3.3	51.6	20.3
Eastern Europe	6%	7%	1.8	12.6	--
Latin America	6%	19%	3.6	48.6	25.9
Near East and North Africa	3%	1%	5.1	27.3	26.0
North America	14%	16%	1.8	29.8	--
Oceania	2%	8%	1.5	19.0	14.0
Russia	0%	0%	1.8	--	--
South Asia	1%	4%	4.8	59.7	24.6
Sub-Saharan Africa	1%	1%	8.5	67.4	30.0
Western Europe	55%	36%	1.7	21.2	18.7

Beyond these differences in country level emissions intensities there is also significant variation within countries. So, the extent of leakage risk depends not only on which countries displace New Zealand production, but which New Zealand farms reduce their production and which farms from offshore increase their production (including new farms that might be created and whether this causes net increases in emissions due to deforestation).

To illustrate the range of possible outcomes which could occur, Table 9 summarises outcomes depending on whether production displaced is at the high, average or low end of emissions intensity for livestock production in temperate zoned grassland production in Oceania. This is then compared with high, average and low intensities for production in all other regions and production types excluding the most emissions intensive areas with low comparative advantage (i.e. excluding production in arid areas).

TABLE 9: MARGINAL LEAKAGE RATES FOR LIVESTOCK AGRICULTURE EXPORTS

Additional global emissions (kg of CO_2e) if 1 kg of NZ emissions is displaced[50].

Dairy			
	Production increased:		
Production displaced:	Low intensity	Average intensity	High intensity
Low intensity	0.04	0.11	0.22
Average intensity	0.00	0.07	0.17
High intensity	-0.14	0.01	0.01

Beef			
	Production increased:		
Production displaced:	Low intensity	Average intensity	High intensity
Low intensity	0.06	0.15	0.26
Average intensity	-0.39	-0.33	-0.27
High intensity	-0.62	-0.54	-0.54

Sheep and goats			
	Production increased:		
Production displaced:	Low intensity	Average intensity	High intensity
Low intensity	-0.11	0.40	0.70
Average intensity	-0.15	0.34	0.62
High intensity	-0.19	0.54	0.54

The results in Table 9 show that if sheep and beef production in New Zealand was displaced by low intensity production from elsewhere in the world there may be a net reduction in

[50] Based on values modelled in Opio et al (2013). Production displaced relates to different intensities of temperate climate production in Oceania. The intensities for where production is increased are taken from the lowest value across all regional groups, except Oceania, for each of the low, average, and high values.

emissions. However, for dairy production, there would only be a net reduction in emissions if high intensity production was replaced by low intensity production.

In general, displacement of New Zealand production would lead to leakage if it is not replaced by low intensity production from elsewhere in the world. The exception is beef production where there is a good chance that leakage would be avoided as long as low intensity New Zealand production is not displaced.

Of course, this analysis leaves open the question of what would happen if dairy and sheep and beef production was displaced by poultry or pork production. It also ignores changes in global demand for meat and other livestock products or a switch to synthetic forms of proteins. Both of these potential changes are worthy of monitoring and ongoing consideration.

But, on current trends, this data does suggest non-trivial leakage risk if only in the near term (the next decade or two). And consumption of animal proteins, including those exported from New Zealand, are not expected to decline any year soon. The OECD and FAO (2018) are currently predicting global consumption of ruminant livestock products to grow, in the next 10 years, by 11% for beef, 20% for sheep meat and 21% for whole milk powder. This compares to 13% for poultry meat and 9% for pig meat.

8. Direct cost impacts are inevitably overstated

Looking at direct impacts on firms, based on current practices, will overstate the effects of climate policy on firm competitiveness. Firms can and do respond to changes in the commercial and regulatory environment. And as global action on climate change gathers pace, markets for sustainable products will expand and innovation will create new and improved ways to add value while limiting or reducing emissions. International evidence gives reason to be optimistic about these dynamics, though local experience is not as positive.

8.1. Firms will respond to changes in costs

Firms faced with rising costs – emissions related or not – will respond and try to reduce those costs. This is clear from experience.[51] Figure 28 provides a stylised representation of the range of forms that responses might take. These include: passing costs on to customers, substituting emissions intensive inputs for alternatives, adopting existing mitigation measures (such as investigating in energy efficiency improvements) through to investigating or adopting new mitigation methods which are not yet known or cost-effective. The question marks in Figure 28 denote uncertainty about the size of these offsetting effects, though the direction of these effect is quite certain.

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.[52]

Most importantly, a market for mitigation or efficiency solutions should drive innovation. Research shows that research and development is boosted by demand pull policies which establish a need for that innovation. Demand pull provides a catalyst for learning by doing (i.e. trying things out and figuring out how they work) and establishing the kind of practical, uncodifiable, knowledge that is often needed for commercial success.

Pricing emissions will also provide advantages to firms which are highly productive and have lower emissions than competitors. This will fuel the usual 'creative destruction' which helps drive innovation in markets – and give it a low emissions flavour.

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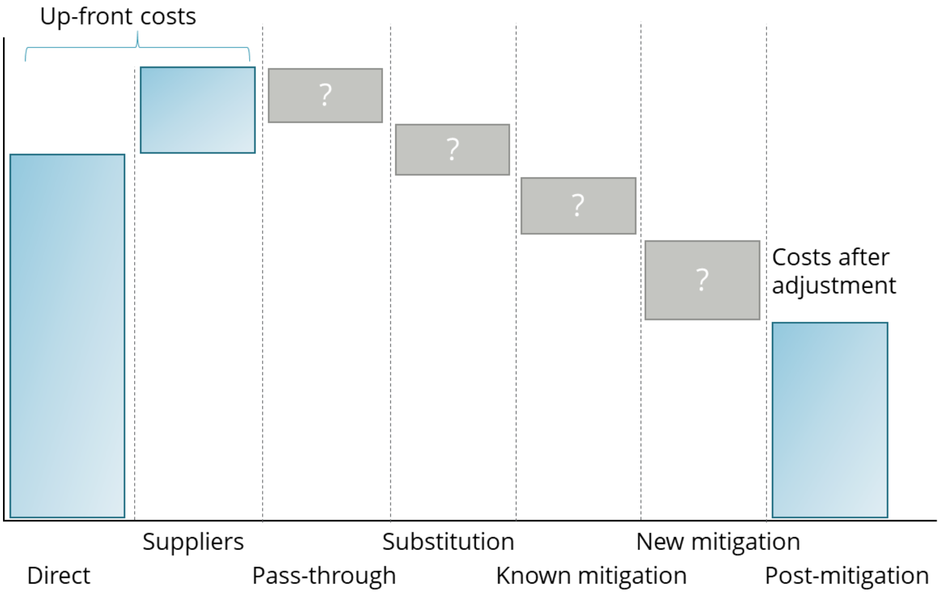
[51] Although, it is not universally true. A survey of New Zealand firms in 2010, showed that a majority intended to either absorb costs or raise prices (Numan-Parsons et al, 2010). However, the survey did show that energy intensive and export-focussed firms were more likely than others to declare an intention to abate, in response to emissions costs.

[52] This literature is not unequivocal. As discussed earlier, some studies do find evidence for reduced productivity or relocation of investment. But these are increasingly in the minority and more recent studies which suggest positive productivity and innovation effects are generally more robust methodologically.

These are all reasons to believe that first order estimates of climate policy costs are likely to be overstated. Not only will climate policy induce innovation it will tilt the innovation playing field in favour of low emission technologies.

FIGURE 28: COSTS FACED BY FIRMS ARE, ULTIMATELY, LESS THAN IS SUPPOSED



8.2. The market for sustainable products is growing

Long term global commitments to emissions mitigation, alongside consumer concerns about sustainability, also promise to increase pay-offs to firms that can demonstrate that their products are comparatively low emission relative to others. And for New Zealand firms, this makes our low emission electricity a commercial asset.

There is no evidence on exactly how valuable this could be for New Zealand producers but there is evidence that demand for sustainable and low emission products is growing and affecting entire value chains because producers of consumer products and consumer durables want low emission inputs. For example, "as the world's largest car companies focus on producing more electric vehicles, they are facing greater scrutiny about the ethical and environmental effects of their supply chains" (Financial Times, December 4, 2017).[53]

8.3. Innovation could accelerate

Once innovation gets going it builds on itself. Studies consistently show that past innovation success predicts future innovation success. And stocks of existing knowledge are an important foundation for growing new knowledge.

[53] https://www.ft.com/content/96cb123a-c9f8-11e7-ab18-7a9fb7d6163e

New knowledge also drives others to innovate or add to the knowledge stock – because they can build on that knowledge (if it is not too costly to obtain).

These so-called 'spill-over' effects mean that New Zealand firms and researchers can use and build on new knowledge being developed elsewhere in the world. And the stock of clean-tech knowledge (measured by patenting) accelerated significantly in the past 2 decades.

There is also some evidence showing that innovation in low emission technologies has been increasing globally as climate policy stringency has increased (Dechezlepretre, 2016). This provides reasons to be optimistic that New Zealand researchers and firms, if encouraged by policy, can connect themselves to this process of innovation acceleration.

And even if new knowledge and invention is not forthcoming in New Zealand, it is the case that firms stand to able to benefit from innovation elsewhere in the world and can use and adapt technologies that have been commercialised elsewhere. A good example of this has been the very rapid decline in costs of battery storage technology and solar PV technologies which New Zealand firms and consumers now have access to.

New Zealand also has relatively limited barriers to adaptation in key sectors such as electricity generation. Research suggests that open markets and competitive markets are important for adoption of renewable energy technologies (Nest et al, 2014).[54]

Indeed, changes in the energy sector – especially storage technologies combined with smart grids and improved demand-side management – promises potential disruptive innovation in the energy sector which, if it lives up to its promise, will improve the efficiency of use of existing infrastructure and increase the ability of the electricity system to integrate intermittent renewables. This could further reduce electricity emissions – potentially to zero – and give firms a competitive advantage internationally – at least as far as electricity is concerned.

There are also reasons to believe that innovation could accelerate in response to strong mitigation signals and predictable increases in emissions prices – beyond what we see in response to typical market shocks.

In general, firms and investors are more likely to respond to credible long-term policy and price signals – in terms of adapting and innovating or investing in energy efficiency and mitigation.[55]

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[54] Although Fowlie (2010) finds that unregulated firms are also less likely to make pollution reducing capital investments. So, deregulation is not necessarily an environmental policy panacea.

[55] Evidence from overseas suggests that firms are more responsive to upfront costs of investment than annual savings on, say, energy efficiency from an investment (see e.g. Anderson and Newell (2004)). This could be a result of uncertainty about pay offs from investment, and this uncertainty could be reduced through credible signals of increasing prices. There is evidence that taxes and policies have a greater effect on emissions reductions than vanilla market price changes (Andersson, 2017; Davis and Killian, 2011; and Martin et al 2014).

In one very detailed and methodologically compelling study of the UK climate change levy, researchers found that firms improved energy efficiency at a rate equal to a 14% reduction in energy used, for every 10% price increase. This is a significant response relative to response sizes usually found in empirical research on responses to energy prices. The authors speculated that this may be because of the peculiar nature of taxes, and their permanence, compared to market prices.

A question, though, is whether or not innovation will be accelerated at a rate which can offset any losses in competitiveness from differences in relative carbon rates.

8.4. Some industries have successfully adapted in the past

Aggregate analysis of industry level responses to energy price shocks suggests that in New Zealand innovation has, in some industries, partially offset changes in energy costs. Although not in every industry. This is summarised in the table below which presents analysis of the impacts of energy price shocks on industry GDP.

Variations in results across industries, endorses views raised earlier about potentially high leakage risks in the metals and food manufacturing sectors.

Quantifying likely impacts of changes in energy prices on industrial sectors can be difficult. Potential impacts can be conflated with both industry-specific factors and national economic factors such as the hangover from the Global Financial Crisis. We need to distinguish effects that originate with energy prices from effects from other sources at a sectoral level.

To identify and quantify impacts from energy prices we use historical data to understand likely effects. Our economic model (more technically, a structural Vector Auto-Regression model that we detail in Appendix 3) uses sectoral output (GDP) and includes both sector specific energy prices and general input prices. We estimate the model for each sector. Table 10 shows the impacts of a one percent increase in the energy price on output 1-,2- and 15-years after the initial shock.

Aside from mining, an increase in energy prices decreases output (value added) for every sector. The energy shock turns out to be persistent (see the charts in Appendix 3), reflecting demand and supply effects in the markets for each sector (i.e. higher costs cause either competitiveness losses or reduced demand). The mining result reflects the fact that mining includes coal mining whose profitability increases when energy prices rise.

In several cases, the reductions in value added are roughly proportional to the change in energy costs. For some sectors this is precisely what might be expected given that direct energy costs are equal to or larger than value added, such as for basic metals where energy input costs are around 50% larger than value added.[56]

[56] Based on the commodity use in the Statistics New Zealand 2013 Input-Output tables.

But perhaps what is most interesting from Table 10 is what is missing – the impact of the increase in energy prices is persistent, even 15 years after the shock there is little evidence of a rebound in output consistent with innovation in response to the shock. Instead, impacts are long-lived.

TABLE 10: HISTORICAL RESPONSES TO ENERGY PRICE SHOCKS

Impact on sector GDP of a one percent sector-specific energy price shock, Jun-87-Dec-17

Sectors	1-year after shock	2-years after shock	15-years after shock
Agriculture, Fishing and Forestry	-0.78%‡	-0.72%‡	-0.57%
Mining	-0.50%‡	-0.18%	0.12%
Food Manufacturing	-0.99%‡	-1.00%‡	-1.17%‡
Textiles	-0.72%‡	-0.61%‡	-0.20%
Wood, Pulp, Paper and Printing	-0.59%‡	-0.62%‡	-0.69%‡
Basic Metals	-0.91%‡	-0.99%‡	-1.07%†
Non-metallic minerals	-0.50%‡	-0.50%‡	-0.68%‡
Mechanical and Electrical equipment	-0.99%‡	-1.11%‡	-1.31%†
Chemicals	-0.50%‡	-0.50%‡	-0.68%‡
Building and construction	-0.91%‡	-1.09%‡	-1.65%‡
Commercial	-0.26%‡	-0.33%‡	-0.49%‡

NB. * Denotes significance at the 10 % level, † denotes significance at the 5% level and ‡ denotes significance at the 1% level. Estimates are based a three-variable VAR estimated using quarterly data over the period, June 1987 to December 2017. We construct a measure of energy prices for each sector and use sign-restrictions to identify the energy price shock (see Appendix 3 for details). Bold font indicates significant at the 80% level.

9. Unclear if NZ firms can adapt to stringent targets

9.1. Firms could have wide gaps to bridge

The size of potential carbon price differentials assessed earlier would pose a significant challenge to firms in maintaining competitiveness through innovation and greenhouse gas mitigation.

The effective carbon rate differentials illustrated earlier can be converted into productivity improvements or emissions reductions (cost reductions) necessary for firms to maintain current output price competitiveness. These rates of improvement (annualised) are presented in Table 11 below. They represent required annual rates of improvement between now and 2050.

As before, these impacts are illustrative only. More than anything else they provide one assessment of how large emissions price and cost differentials could get.

The results in Table 11 are based on trade weighted effective carbon rate differentials, so different required rates of improvement partially reflect different markets with different effective carbon rates (as shown in the previous section). They also reflect different emissions intensities and are on top of assumed rates of business-as-usual efficiency improvements (i.e. their effect on emissions intensity have already been taken into account in the numbers Table 11).

There are 4 scenarios in Table 11. Two reflect assumptions about whether on-farm emissions are included in a climate target and in the ETS (or some other price-based policy). The other scenarios are based on global action with current NDCs or with adjustments to NDCs that are consistent with 2 degrees of global warming.

These rates of improvement need to be additional to current productivity growth for industries to maintain their competitiveness. And every year that they fall behind would need to be made up by more than doubling the rate of improvement in the subsequent year, for example.

The presentation in Table 11 is, of course, artificial. But it usefully provides a basis for comparison with current rates of productivity growth. 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.

TABLE 11: RATES OF IMPROVEMENT TO MAINTAIN COMPETITIVENESS

	Current ETS scope		**Expanded ETS scope**	
Industry	NDC	2 degrees	NDC	2 degrees
Cement	2.8%	2.5%	2.8%	2.5%
Chemicals	3.0%	2.1%	2.8%	2.0%
Dairy	1.0%	0.0%	1.6%	0.4%
Dairy cows	1.6%	1.0%	2.4%	1.9%
Fishing	1.8%	0.8%	1.8%	0.8%
Forestry	0.0%	0.0%	0.0%	0.0%
Furniture manufacturing	0.0%	0.0%	0.0%	0.0%
Horticulture	1.3%	0.3%	2.3%	1.4%
Meat	1.1%	0.8%	2.4%	2.1%
Mining	1.3%	0.0%	1.3%	0.0%
Other farms	1.8%	1.2%	2.8%	2.2%
Paper	0.3%	0.0%	0.3%	0.0%
Petroleum	2.5%	1.3%	2.5%	1.3%
Primary metals	2.7%	1.7%	2.7%	1.7%
Seafood	1.0%	0.4%	1.3%	0.6%
Sheep and beef	1.9%	1.4%	2.9%	2.4%
Textiles	1.1%	0.8%	2.3%	2.0%
Wood	1.1%	0.0%	1.1%	0.0%

The history of productivity growth in these industries shows that it would take a significant break with history to meet these rates of improvement (see Figure 29).

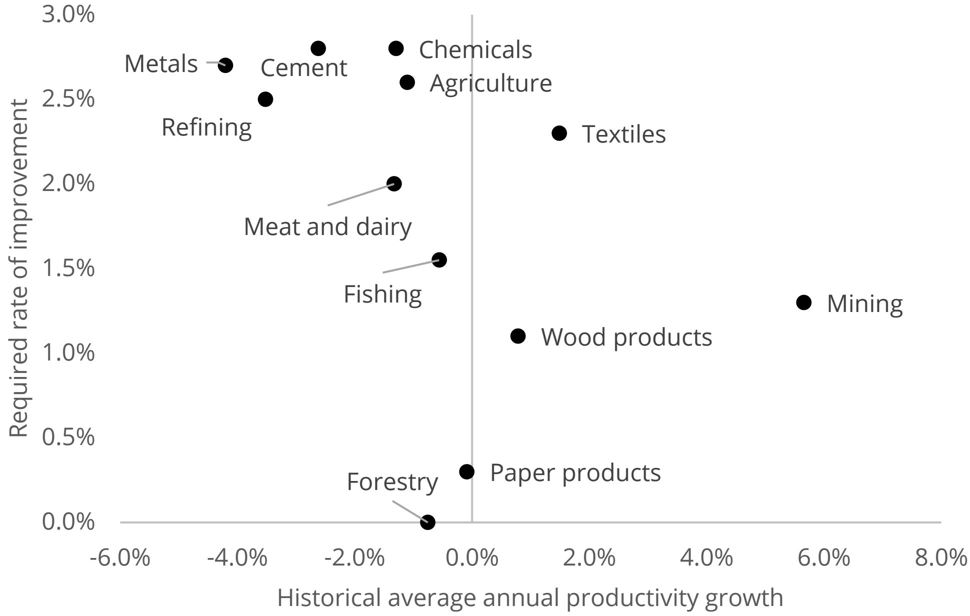
It is also notable that sectors which have high leakage risk have, typically, not experienced strong productivity growth in the past. Indeed, most of these industries – in particular steel, cement and aluminium – are not industries in which New Zealand has any comparative advantage or pre-existing distinctive stock of knowledge. This means that future emission reducing innovation and productivity gains, of meaningful scale, are not likely to occur here, in these sectors, even with policy support.[57] That is, support for innovation is likely to be best targeted at diffusion of new ideas as and when they arise.[58]

An obvious exception to this observation is livestock agriculture where New Zealand does have some distinctive advantages and existing knowledge and skills that can be leveraged to promote emission-reducing innovation.

[57] For example, there are several initiatives in the world to pilot low emission steel production (e.g. in Norway and Austria). These initiatives cost billions of dollars and would not find a natural home in New Zealand.
[58] Much as it already is, as noted earlier in terms of support being provided to Golden Bay cement to adopt well known emission reducing practices.

FIGURE 29: PRODUCTIVITY GROWTH VS REQUIRED IMPROVEMENT

Multi-factor productivity growth (2001 to 2012) of firms that are high productivity ('frontier') vs required rate of improvement given NZ NDC and expanded ETS scope (column 3 Table 11)[59]



9.2. Weak track record for innovation-led productivity growth

New Zealand's economy has been characterised as being in trapped in a 'low productivity growth equilibrium' (Conway, 2016) with:

- weak international connections
- small and insular markets
- low capital intensity
- weak investment in knowledge-based capital.

No-one is exactly sure why this equilibrium exists or how to fix it. But low rates of innovation are both a symptom and a candidate cause.

Some have suggested that this is a consequence of some rather ingrained attributes of the New Zealand economy – that the New Zealand economy is small and remote.[60] Being small and remote adds costs to trade and to acquiring knowledge. It also limits competition which limits the need to innovate and reduces returns to innovation

[59] Data from Conway (2016) Fig 3.8 (b).

[60] Crawford et al (2007) found that New Zealand's low level of R&D was consistent with being distant from major markets, having a large agricultural base, and small average firm size.

Other reasons put forward for New Zealand's productivity and innovation malaise are variants on a self-reinforcing cycle of under-investment in knowledge, being behind the pace relative to global performance and best practice (the productivity frontier), and a lack of absorptive capacity.

Officials from the OECD (de Serres et al, 2014) have investigated potential reasons for New Zealand's relative under-performance in productivity growth and find that:

> *"remote access to markets and suppliers and low investment in innovation (as measured by R&D intensity) could together account for between 17 to 22 percentage points of the 27 percent productivity gap vis-à-vis the average of 20 OECD countries".*

9.3. NZ impediments apply equally to emission reducing innovation

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).

Other studies show that diffusion of low emission technology is negatively related to geographical distances as well being behind the pace technologically (Verdolini & Galeotti, 2011).

9.4. Innovation to reduce emissions could worsen NZ's low productivity growth equilibrium

Recent research indicates that the strength of foreign direct investment, exports, and the manufacturing sector all enhance capacity to take on new ideas and drive productivity growth (Harris and Le, 2018). If climate policy does negatively affect competitiveness it may well weaken each of those factors and thereby reduce the very rates of innovation needed to offset relative cost differences.

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. This could reduce growth in living standards, while low emission growth dynamics need productivity growth to lift incomes to spur demand for new and lower emission technologies (Gans, 2012).

Indeed, there is likely to be a 'sweet spot' or threshold for climate policy and if policy is too stringent it could reduce firm productivity and innovation to solve environmental problems. For example, Johnstone et al (2017) showed innovation in the energy sector is driven by environmental policy stringency, but this effect turns negative beyond a threshold as resources are diverted "from production of the final good (electricity) to abatement efforts to meet policy requirements" (p.113).

10. Concluding remarks

Prospects of significant differences in costs raise questions about the capacity of New Zealand firms to innovate and obtain offsetting sources of competitive advantage.

Certainly, the overseas evidence provides qualified support for significant adjustment and potentially positive responses. So, it would be a mistake to presume that first order cost impacts tell the full story although many evaluations conducted before-the-fact have jumped to exactly that conclusion. And the analysis presented in this report does defer to international experience and academic research in arguing that climate policy targets are likely to increase firm-level innovation.

But empirical evidence about innovation, evidence that is applicable to New Zealand and to climate policy, is hard to come by. 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.

But, conclusions of negative impacts are also highly speculative. They should be taken as cautionary notes and not predictions. In any case, competitiveness is a two-sided coin and competitiveness effects depend to a large extent on policy developments overseas. Actual impacts will depend on how fast and how stringently climate policy is applied, both here and overseas.

Much could change with new climate policy pledges under the Paris Agreement. In the meantime, a credible long-term target would provide valuable signals to firms, if that target is accompanied by sufficient policy flexibility to be able to adapt policy settings to events here and abroad. And acknowledging that other countries are doing the same and will continue to do so.

It is worth reflecting too that most studies which examine competitiveness effects assume emissions prices which, ultimately, never come to pass. And one of the reasons for this is transitional measures and exemptions to carbon pricing which followed assessments of competitiveness effects.

Policy has consistently undermined demand for mitigation and therefore prices have been low. This is a quandary, how to raise prices to see what they do when you believe you already know what they will do.

Appendix 1: Data sources

Industry emissions intensities and costs

Estimates of emissions intensities and emissions by industry follow the methods used in Allan & Kerr (2015) based on input output tables (2007, 2013). Additions to their approach include:

- Interpolating emissions for years without input output table data using emissions registry data, MBIE fuel use data, activity data from the Statistics New Zealand manufacturing survey[61] and
- Splitting key emitting activities out from their industries: primary metals emissions and activity into aluminium and steel; and non-metallic minerals into cement and other.

Emissions costs are estimated by marking the value of emissions to the average market price of NZUs and adjusting for reduced (e.g. two-for-one) surrender requirements. EPA data on allocations of free allowances, by recipient, is used to estimate the impact of reductions in costs due to free allocations. Free allocations are also valued at the market price of NZUs in the year the allocations were provided.

Analysis of industry profitability is based on National Accounts data. National Accounts data is at a higher level of aggregation than input output data. So, activity and emissions and emissions costs information are aggregated to match National Accounts data.

Trade data

To analyse trade by industry we match export trade data to industries based on a bespoke correspondance between HS (4 digit) product codes and ANZSIC06 industry classification (8 digit). This correspondence is constructed using mappings: from the Australian Bureau of Statistics for ANZSIC06 to ISIC (Rev 4); UN mappings from ISIC (rev 4) to CPC product codes; and UN correspondences for CPC codes to HS codes. Products produced by multiple industries are assigned to a single industry using judgement based on New Zealand industry production.

Import data is matched on the same basis – reflecting our interest in import competition rather than imports by industries.

[61] In some cases, this involves assigning industry activity growth for a combined industry to sub-industry components (due to there being fewer national accounts industries for which data in available or high levels of aggregation for energy data). To do this we assume that relative growth rates between sub industries between 2007 and 2013 persist through time and we assign industry growth according to the relative shares of growth.

Trade data is gathered from Statistics New Zealand's monthly data on trade by country by HS10 digit line for the period January 2000 to December 2017. This differs from the data in our international trade models, discussed in Appendix 2, where the data is from UN Comtrade.

There are shortcomings to industry level analysis. This is because an industry's output will consist of a range of products with varying emission intensities. Some will be higher intensity than others. But our estimates of impacts will be at the average. This is a major issue for many sectors such as horticulture and fruit growing where there are widely varying production technologies in terms of energy intensity and for dairy manufacturing where there is significant variation in fuel use.

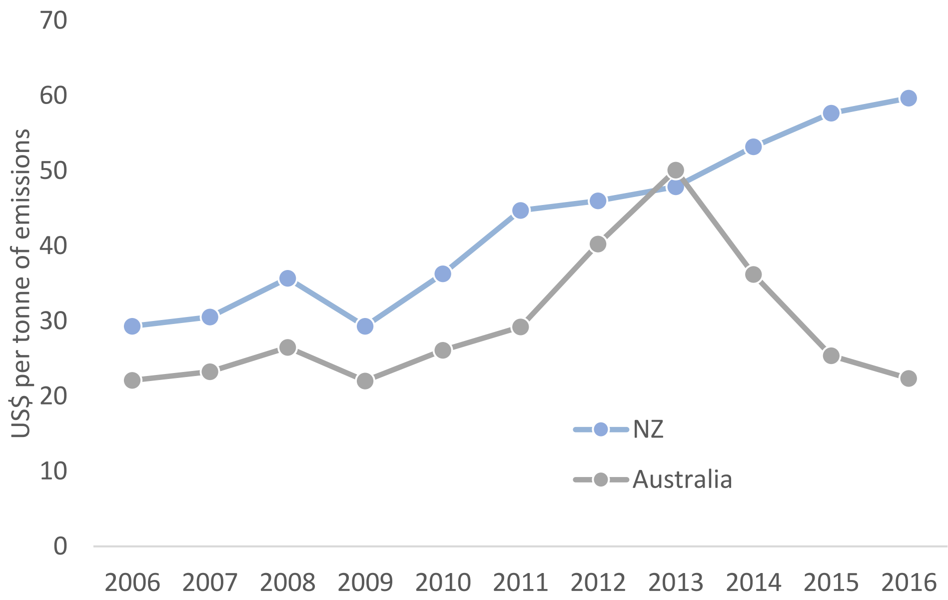
Furthermore, different industries produce the same products. Those products could be high intensity, for example, while the industries have different average intensities.

Appendix 2: Analysis of trade, impacts of the ETS

For a small open economy, trade flows are a key channel through which competitiveness and leakage effects occur.[62] To explore the impact of climate policy on trade flows we examined New Zealand and Australia exports and imports with the world and the influence of effective carbon rates on trade.

Changes in climate policy in Australia provide a natural experiment for understanding the effects of climate policy on trade. Australia had explicit prices on carbon from the middle of 2012 until the middle of 2014 (as shown in Figure A.2.1).

FIGURE A.2.1: EFFECTIVE CARBON RATES IN NEW ZEALANDA AND AUSTRALIA



We find weak evidence of an association between increased effective carbon rates in New Zealand and Australia and falling exports and rising imports.

The general model we use is the so-called gravity model, in logarithms:

$$x_{i,j,s,t} = \alpha_s + \gamma_t + \theta_j + \beta y_{i,j,t} + \delta F_{i,j,t} + \psi P_{i,j,t}$$

Where exports (x) from sector s and country i to country j is a function of trade frictions (F) economic mass (y), and carbon and energy price and other price-cost measures (P). We also include fixed effects by sector, year and trading partner ($\alpha_s, \gamma_t, \theta_j$).

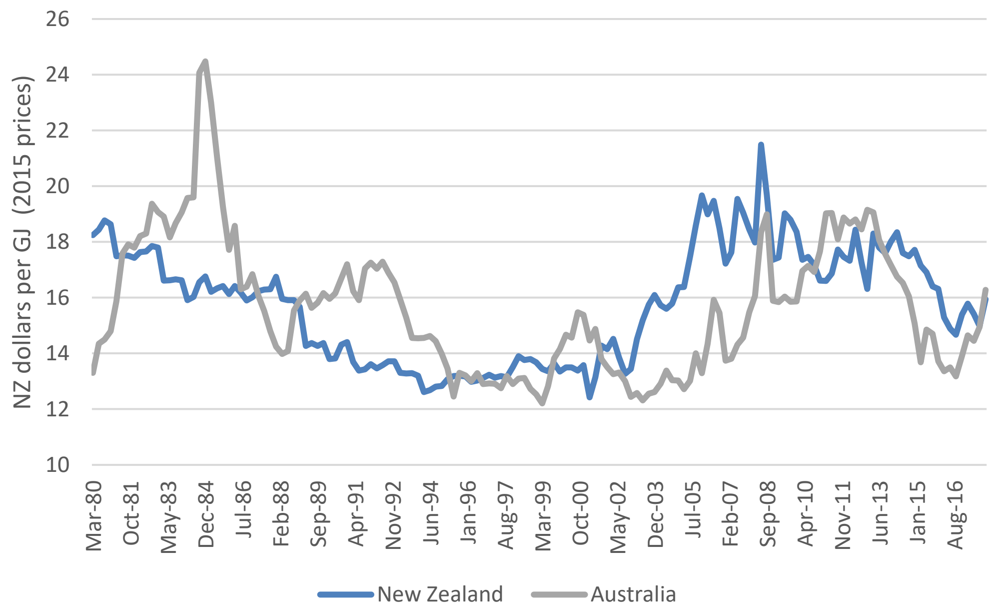
[62] Investment flows can also be an important channel, but ultimately the environmental impact – in terms of leakage – will occur through increased imports or reduced exports. And the 'price channel' for leakage is generally only of concern for large markets and for global policy coordination. It is not something that is likely to be affected by New Zealand policy.

Data for the models is:

- Export and import data, from UN Comtrade, for EITE industries aggregated to the industry level (as discussed in Appendix 1)
- Data on frictions and related institutional variables, from CEPII, comprising: Distance between trade partners; whether trade partners are parties to a bilateral or regional trade agreement; whether a trade partner is in the EU; time differences between trade partners; whether trade partners share a common official language.
- Economic mass calculated as the product of trading partners' GDPs divided by world GDP, using data from the World Bank
- Effective carbon rates (see Appendix 1) and energy price indices for New Zealand and Australia which have been constructed for this analysis (see Figure A.2.2), plus real exchange rates from the Bank for International Settlements.

The trade data is limited to trade between New Zealand and the rest of the world and Australia and the rest of the world. This is because we do not have data on energy prices by all countries or data on effective carbon rates over time for all countries.[63]

FIGURE A.2.2: WEIGHTED AVERAGE INDUSTRIAL ENERGY PRICES IN NEW ZEALAND AND AUSTRALIA



There are 47 trading partners included in the data for the models. Each of the 46 countries for which we have measures of effective carbon rates plus a 'rest of the world' trading partner.

[63] This was simply due to time limitations.

Four models have been fitted:

- A model of exports from New Zealand and Australia
- A model of imports to New Zealand and Australia
- A model of net imports to New Zealand and Australia
- A model of New Zealand and Australian export market shares (by country).

The first three models are fitted using log-linear models comprising fixed effects and random country effects, following the approach in Genç and Law (2014). This includes the use of a two-step procedure, with a selection model to account for instances of zero trade.

The export shares model is a panel logit model (quasibinomial) with country, year and industry fixed effects.

The models are fitted on data for the years 2006 to 2016 (inclusive).

Summary results for each of the models are presented in tables A.2.1-A.2.4 below – excluding fixed effects coefficients.

Results from the exports model suggest a large negative effect of effective carbon rates on export trade (-10% for each 1% increase in carbon rate) but that effect is dependent on energy price levels (captured in the variable 'Energy price x Effective carbon rate'). Increases in energy prices reduce the effect of effective carbon rates – perhaps reflecting a demand-side effect where higher energy prices reflect increasing income-related export demand which is driving up energy prices. In net, evaluated at the average, the effect of a 1% increase in the effective carbon rate is to reduce exports by 6.4%. This is consistent with the size of price elasticities of export demand. However, the estimate is not very precise. We cannot reject a hypothesis that the true effect is zero.

TABLE A.2.1 RESULTS FROM EXPORTS MODEL

Dependent = log(Exports) by industry, trade partner and year

Variable	Estimate	Standard Error	t-stat	Significance
Intercept	1138.8	207.7	5.48	****
Mass	0.7	0.2	4.23	***
Mass, average	-13.7	2.5	-5.42	***
FTA	0.4	0.2	2.12	**
FTA, average	-0.6	0.6	-1.10	-
Energy price (in NZ or Australia)	-14.9	7.9	-1.89	-
Energy price, average (in NZ or Australia)	-296.4	55.9	-5.30	***
Distance between trade partners	-0.1	0.5	-0.27	-
Trade partner in EU	6.1	46.9	0.13	-
Effective carbon rate (in NZ or Australia)	-10.0	6.9	-1.46	-
Trade partner shares a common language	-1052.7	251.2	-4.19	***
Real exchange rate (in NZ or Australia)	2.9	2.1	1.43	-
Energy price x Effective carbon rate	3.6	2.5	1.45	-

Significance levels: **** 1%, *** 2%, ** 5%, *10%, - >10%.

The results from the imports model, in Table A.2.2, show similar sized effects as for exports but with the opposite signs – which is what we would intuitively expect. The effect of effective carbon rates on imports is mediated by energy price levels with the net effect, evaluated at the average, implying a 4% increase in imports for a 1% increase in effective carbon rate. But here too the model is not sufficiently precise for us to reject the idea that the true effect may be zero.

TABLE A.2.2 RESULTS FROM IMPORTS MODEL

Dependent = log(Imports) by industry, trade partner and year				
Variable	Estimate	Standard Error	t-stat	Significance
Intercept	167.7	170.8	1.0	-
Mass	-0.1	0.1	-0.9	-
Mass, average	-1.4	2.1	-0.7	-
FTA	0.1	0.2	0.4	-
FTA, average	-0.9	0.5	-1.9	*
Energy price (in NZ or Australia)	7.7	6.5	1.2	-
Energy price, average (in NZ or Australia)	-60.0	46.0	-1.3	-
Distance between trade partners	0.4	0.4	1.0	-
Trade partner in EU	-45.1	38.5	-1.2	-
Effective carbon rate (in NZ or Australia)	7.7	5.7	1.4	-
Trade partner shares a common language	-255.8	206.5	-1.2	-
Real exchange rate (in NZ or Australia)	3.7	1.7	2.2	**
Energy price x Effective carbon rate	-2.8	2.0	-1.4	-

Significance levels: **** 1%, *** 2%, ** 5%, *10%, - >10%.

The net imports model reflects the net of the import and export dynamics. Effective carbon rates are estimated to increase net imports (i.e. decrease exports or increase imports) by a net 2.4% for each 1% increase in effective carbon rates after accounting for interactions with energy price effects. Unlike the other two models this result is significant (at the 5% level).

Results from the export market shares model is more equivocal than for the net imports model. The results shown here, in Table A.2.4, suggest a negative effect of the effective carbon rate of a 0.2 percentage point reduction in market share (see 'Marginal effect' column), on average, for a 1% increase in effective carbon rate. But, this is not statistically significantly different from zero, so we cannot be very confident about the precisions of the estimate. And, most importantly, this example excludes the effects of an interaction with energy price levels. If we include this 'interaction effect' the sign of the coefficient on effective carbon rates changes and the effect becomes positive. So, we downplay the results of the analysis and conclude that while we observe some evidence of negative effects of effective carbon rates on trade the evidence is weak.

These results, are of course only some of the many possible model specifications and variables which could be used to analyse trade flows. Here we have shown a consistent set of results (in terms of predictors), to reduce (but not eliminate) problems that can arise from selective presentation of results and mining the data for significant coefficient values.

TABLE A.2.3 RESULTS FROM NET IMPORTS MODEL

Dependent = Net imports (normalised to have mean =0) by industry and trade partner and year				
Variable	Estimate	Standard Error	t stat	Significance
Intercept	-327.2	49	-6.7	****
Mass	-0.2	0	-3.8	***
Mass, average	4.0	1	6.7	***
FTA	0.2	0	3.4	***
FTA, average	0.7	0	4.8	***
Energy price (in NZ or Australia)	3.7	2	2.0	**
Energy price, average (in NZ or Australia)	84.2	13	6.4	***
Distance between trade partners	-0.2	0	-1.8	*
Trade partner in EU	-17.6	12	-1.5	-
Effective carbon rate (in NZ or Australia)	3.7	2	2.3	***
Trade partner shares a common language	250.9	60	4.2	***
Real exchange rate (in NZ or Australia)	0.8	0	1.6	-
Energy price x Effective carbon rate	-1.3	1	-2.3	**

Significance levels: **** 1%, *** 2%, ** 5%, *10%, - >10%.

TABLE A.2.4 RESULTS FROM EXPORT MARKET SHARE MODEL

Dependent = export share of destination market by industry, destination and year				
Variable	Coefficient	Standard Error	Marginal effect	Significance
Intercept	-724.66	114.83	-12.634	****
Mass	0.19	0.06	0.003	****
Mass, average	9.01	1.41	0.157	****
FTA	0.00	0.07	0.000	-
FTA, average	-0.78	0.23	-0.014	****
Energy price (in NZ or Australia)	-0.52	0.56	-0.009	-
Energy price, average (in NZ or Australia)	188.52	30.89	3.287	****
Distance between trade partners	-0.52	0.26	-0.009	**
Trade partner in EU	3.63	20.44	0.063	-
Effective carbon rate (in NZ or Australia)	-0.10	0.16	-0.002	-
Trade partner shares a common language	777.39	131.56	13.553	****
Real exchange rate (in NZ or Australia)	1.17	1.02	0.020	-
Energy price x Effective carbon rate	na	na	na	na

Significance levels: **** 1%, *** 2%, ** 5%, *10%, - >10%.

In our view this analysis could usefully be extended with more time and if data could be obtained or constructed on energy prices and effective carbon rates in key markets over time. While country-specific energy price data has been used to study trade patterns in the past (e.g. Sato and Dechezlepretre, 2015) that data it is now outdated and was not, in any case, available to us for this research.

Appendix 3: Industry responses to energy price shocks

Estimating the impact of energy price shocks on New Zealand's industries

Directly quantifying likely impacts of the prices shocks on New Zealand industries is not straight-forward. We need a model or mechanism that can separate impacts that come from changes in energy prices from a myriad of other potential impacts, including demand for goods and services within each sector.

Usefully, many studies (see Kilian and Murphy 2012 for an overview of the issues) examine an almost identical problem: estimating the impact of changes in energy prices on the economy. These studies examine a range of other countries including the US, Korea (Chuwan et al. 2011), OECD countries (Jiménez-Rodríguez 2011) and the Euro area (Peersman and van Robays 2009).

These researchers all use the same structural VAR technology to distinguish the impact on industry output from changes in energy prices. Our VAR model is the following:

$$y_t = B(L)y_{t-1} + \epsilon_t \quad (1.)$$

where the vector y_t contains three variables: (i) x_t^i that is quarterly real industry output from Statistics New Zealand's national accounts data, (ii) p_t^i that is an industry-specific input price series and (iii) en_t that is a quarterly real energy price index constructed for New Zealand. The error vector, ϵ_t, is normally distributed so we can estimate equation (1) with Ordinary Least Squares. The matrix of coefficients $B(L)$ describes the relationships between our 3 variables and allows for up to additional L lags in each data series.

But rather than uncovering statistical relationships, we want to uncover the structural relationships between movements in energy prices that originate in energy markets and movements in energy prices from other factors, such as firms facing additional demand for goods and services in their industry and demanding more energy that in turn raises prices.

Uncovering a structural relationship

To uncover a structural relationship, we recast equation (1) by pre-multiplying by a parameter matrix A_0^{-1} that captures the contemporaneous relationship between our variables, that is:

$$A_0^{-1}y_t = A(L)y_{t-1} + e_t \quad (2.)$$

where the error matrix e_t is normally distributed.

At least in principle, changes in energy prices can increases costs for some New Zealand industries, we are particularly interested in finding the structural impact of changes in price, or shocks to the price of energy that increase costs. We want to rule out changes in energy prices that originate from firms that are facing increased demand for their goods and services and are looking to increase production. In the nomenclature of the studies we follow, we impose sign restrictions on how energy price shocks impact on variables over time to identify impacts.

That is, we want to limit the set of models we work with such that the matrices A_0 and A_1 return paths or *impulse responses* for each variable that agree with our characterisation of the impact of shocks to the cost of energy that are expected to reduce industry output.

Technically, we can impose these constraints (a_j^0, a_j^1) with restrictions on the A_0 and A_1 matrices such that the j-th column of matrices A_0, A_1 show how the structural shocks in e_t trace the dynamics in the variables of interest y_t. We can use a sequence of matrices $\Psi_0, \Psi_1, \Psi_2, \Psi_3 \dots \Psi_k$ where k is the horizon (quarters, years) or how long we want to restrict outcomes.

Shocks that are generate from increasing demand would be expected to increase both industry output and energy prices. We are not particularly interested in these shocks since they don't shed light on the impact of the Emissions Transmission Scheme.

Uncovering the impact of energy shocks

We want to know the impact of energy price shocks on a range of industries and start with a relatively simple model that contains industry output, industry input costs and an industry-specific energy price index.

This model allows us to identify the impact of demand shocks, supply shocks and energy prices shocks. Table 1 shows the restrictions we impose on the models.

TABLE A.3.1: WE RESTRICT THE SIGN OF IMPACT TO IDENTIFY STRUCTURAL SHOCKS

Variables	Demand shock	Supply shock	Energy price shock
Industry output (real)	+	-	-
Industry costs (PPI-inputs)	+	+	
Energy price index	+		+

Table A.3.1 shows that a positive demand shock is expected to increase output and costs as firms try and increase capacity. Demand for energy might be expected to increase in response to the demand shock (for example, to run factories for longer).

Positive supply shocks increase costs of producing goods and services. Firms might be expected to either reduce production or increase output prices. Increasing output prices can be expected to decrease demand so we expect a negative impact on industry output from a positive supply shock. It's not clear what might be expected to happen to energy prices so we leave energy prices unrestricted.

Since energy prices comprises a slice of general costs, a positive energy price shock increase industry costs. When energy prices increase, firms face a similar decision: reduce output immediately or pass on price increases that can be expected to decrease consumer demand at a future point. So, to identify an energy price shock we impose the restriction that industry output must fall in response to an increase in energy prices.

Results

Figures A.3.1 to A.3.3 show the impacts of a sector-specific energy shock on output, input prices and energy prices for each of the industries we have sufficient data to consider. For each industry, the right-most panel shows the impact – and persistence – of the shock we consider: a one standard deviation shock to the energy price (in logs). The middle panel shows the impact on sector prices and the initial panel shows the impact on sector output.

Since we take the natural logarithm of our data and then estimate the structural VAR in levels rather than growth rates, we can interpret the vertical axis as the percent change in the variables of interest. For example, for Agriculture, Fishing and Forestry, a one standard deviation energy shock (about $1.10 per gigajoule at the end of 2017) generates an initial decline in output of a little over 2 percent that moderates over several quarters.

It is worth noting the point estimates contain considerable uncertainty. The dashed lines show 10-and 90-percent quantiles such that the region between the dashed lines is an 80 percent confidence interval for the estimate of the impact. At least for Agriculture, Fishing and Forestry, the upper band is positive, so our model suggests there is no significant impact of energy shocks on Agriculture, Fishing and Forestry. Interestingly, even though our energy shocks are specific to the sector, the impact of the energy shock has a very muted impact on general input prices for Agriculture, Fishing and Forestry.

Figure A.3.1 shows the impact of sector specific energy shocks on mining is small. The initial shock is relative large (a 4 percent increase in energy prices) but after some initial impact, output rapidly returns to zero – so the shock has had a very limited impact on output. Moreover, the confidence bands are wide -we cannot detect any material impact of a shock to energy prices in the mining sector on output.

Our results show some impact of energy prices on food manufacturing. The initial shock to energy prices is about 3 percent and generates something close to a 2 percent fall in output that persists over time. This suggests there is little firms in the sector can do to limit the impact of the shock on output. Although there is some uncertainty around our central estimate, the confidence-bands are both negative – so we should be comfortable that there is some significant impact of changes in the prices of energy on output.

The impact of a change in energy prices in the textile industry is shown in Figure A.3.1. The initial shock increases prices by over 3 percent and output falls initially by a similar margin. The confidence bands are wide however and we cannot conclude there is any significant impact of changing energy prices on output in the textile sector.

FIGURE A.3.1: IMPACTS OF ENERGY SHOCKS ON SELECTED INDUSTRIES

(i) Agriculture-Fishing-Forestry, (ii) Mining, (iii) Food manufacturing, (iv) Textiles

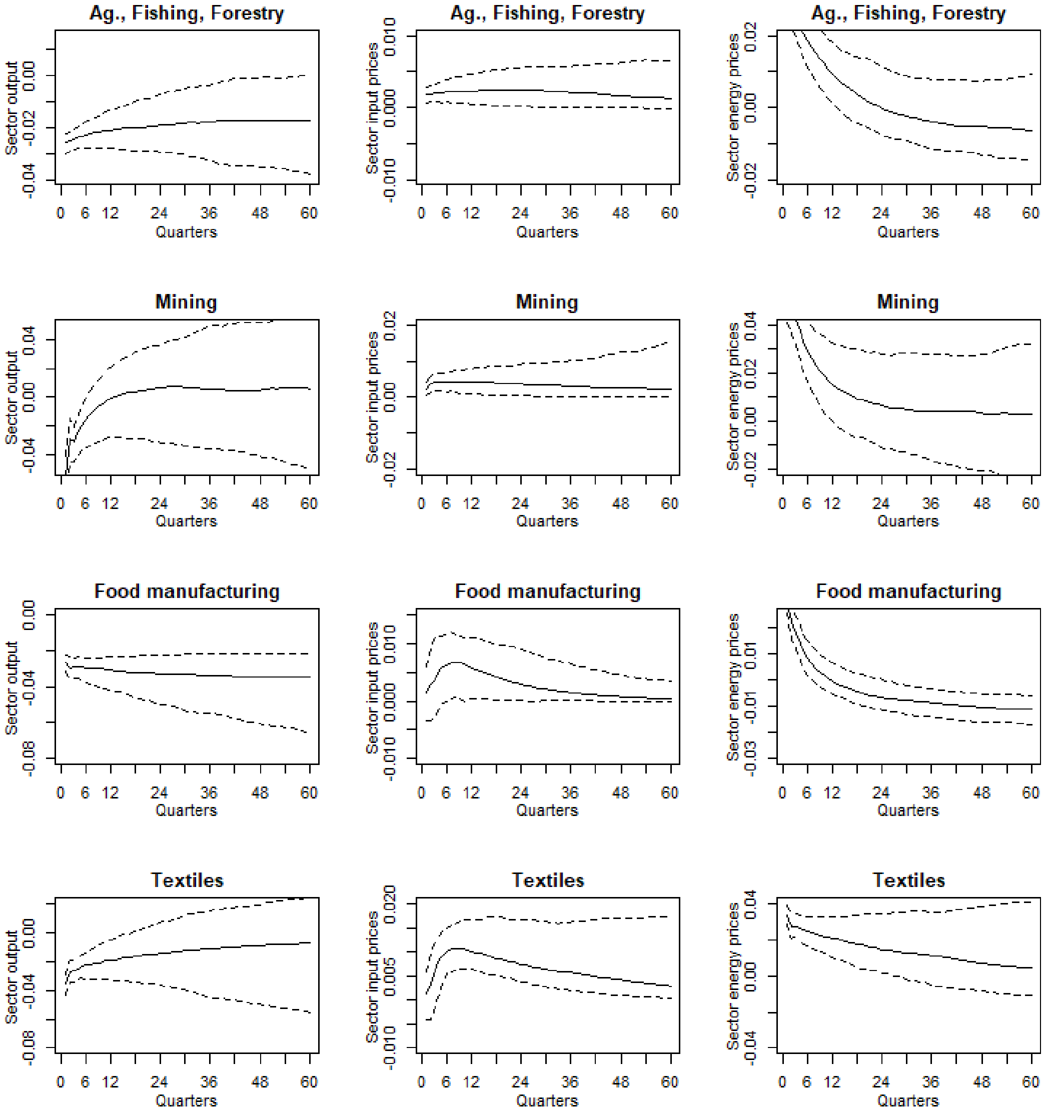


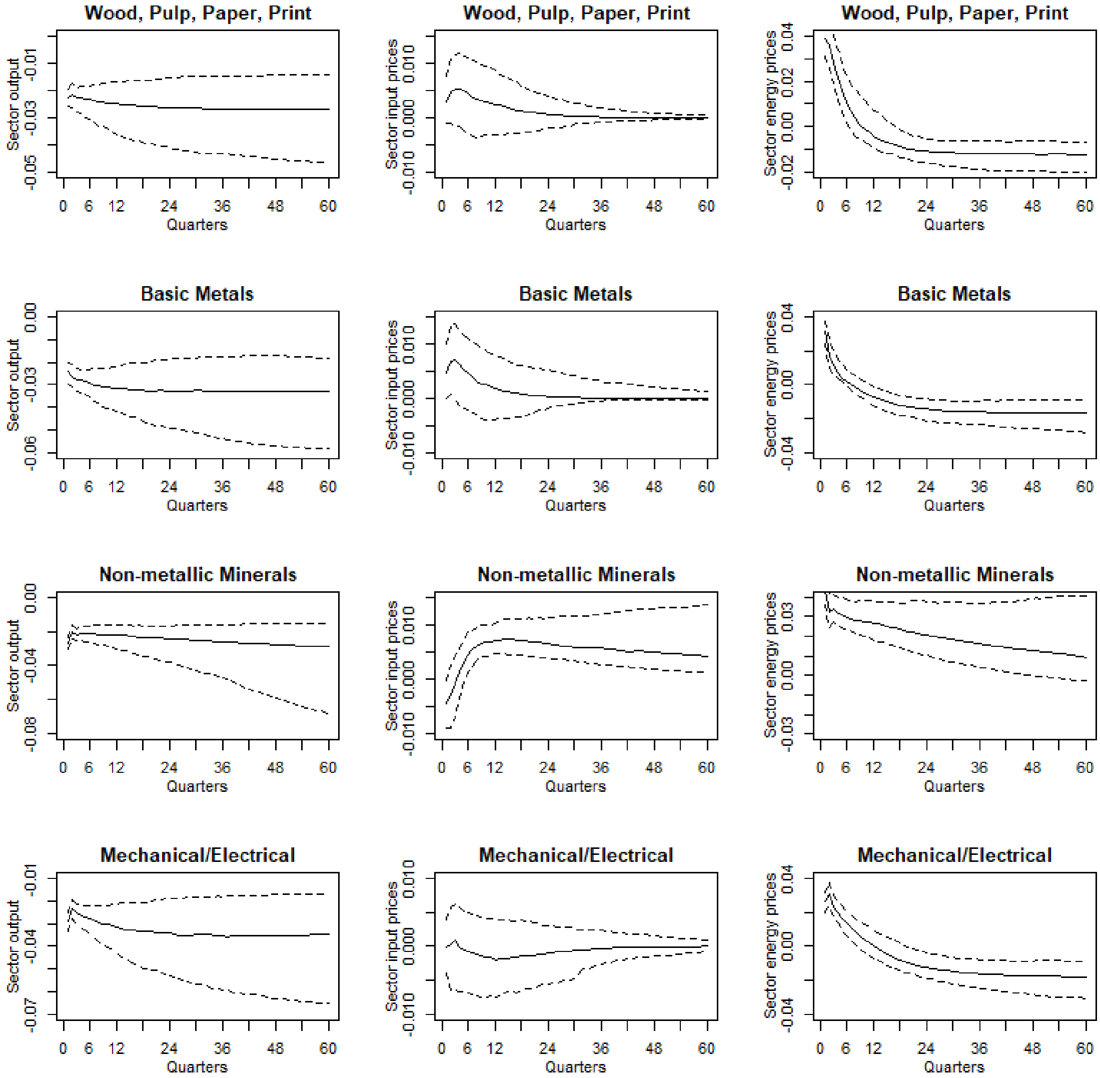
Figure A.3.2 depicts how changes energy prices impact on output in wood, pulp, paper and printing, basic metals, non-metallic minerals and electrical/mechanical equipment.

For wood, pulp, paper and printing, there appears to be a significant impact. After an initial shock to energy prices to the sector of about 4 percent, output remains about 2.5 percent lower some two years after the initial shock. That comprises a decrease in output of about $17.5 million dollars in real terms. If firms could innovate and increase output in response to the shock, we would expect a hockey-stick or "j" shaped response to the shock. Instead, the impact is very persistent

Basic metals also shows some impact of energy prices on output. A one standard increase in the energy prices for the basic metals sector decreases output by about 2.4 percent initially. The confidence bands indicate the impact is significant and again, persists over time.

An increase in energy prices of almost 4 percent decreases output by about 2 percent in the for non-metallic minerals sector. However, it is worth noting that the increase in energy prices also generates a significant increase in the input prices for this sector, either as a direct input to the index or indirectly, by lifting the prices of other goods and services that supply the sector. So, we need to interpret out initial findings with some caution.

FIGURE A.3.2: IMPACTS OF ENERGY SHOCKS ON SELECTED INDUSTRIES
(v) Wood, Pulp, Paper, printing, (vi) Basic metals, (vii)Non-metallic metals, (viii) Mechanical/Electrical equipment

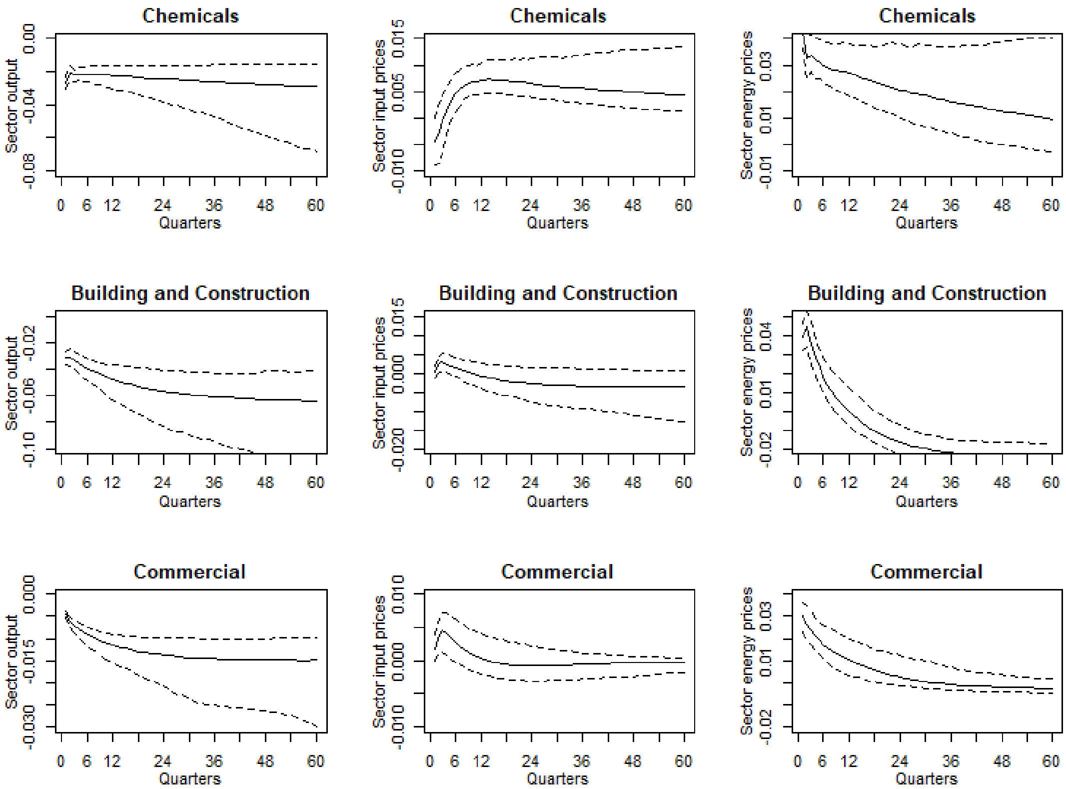


Production of electrical/mechanical equipment shows energy price increases lower output. Output falls by about 2 percent after the shock (that comprises an increase in energy prices in the sector of a little under 4 percent). It is worth pointing out that our method estimates impacts of changing energy prices from both increases and decreases in energy prices. If there are asymmetric impacts, such that an increase in energy prices has a different impact magnitude to an equal sized decrease in energy prices, then our estimates will be biased.[64]

We show the impact of an energy price shock on chemicals production in the first panel of Figure A.3.3. A 4 percent increase in energy prices reduces output by about one percent – an impact that persists over time.

FIGURE A.3.3: IMPACTS OF ENERGY SHOCKS ON SELECTED INDUSTRIES

(ix) Chemicals, (x) Building and construction, (xi) Commercial



The building and construction output falls after an increase in energy prices. Some 36 quarters after the initial increase in energy prices of a little over 4 percent, output is 6 percent lower under our baseline estimate. Clearly impacts are persist and show little rebound in activity in response to the shock. The confidence intervals suggest a statistically significant impact.

The last row of Figure A.3.3 shows the impact of energy prices on commercial activity. A 3 percent increase in the price of energy in the commercial sector decrease output by a little

[64] Testing this would require substantially more resources.

over 1 percent even some years after the initial shock. Other input prices increase a little, but the impacts are not significantly different from zero.

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