Improving access to agricultural and horticultural products

Scenario analysis of economic impacts

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Summary

This analysis assessed the potential economic benefits of improving access to regulated agricultural and horticultural products in New Zealand, focusing on three scenarios examining the costs of regulatory delays and impeded access to new products.

Scenario 1: Delayed diffusion of innovation

- Faster access to new products, across all agricultural sectors, can lift primary sector productivity.
- Halving regulatory approval times could generate benefits of $272 million (present value) over 20 years.
- Annual benefits peak at $64 million after 15 years, equivalent to 0.4% of agricultural GDP.

Scenario 2: EU market access risk for fruit and vegetables

- New Zealand growers need access to new products to stay ahead of international standards for agricultural chemical use while maintaining product quality.
- We examine the potential impact of new regulations in the EU and value the risk of lost market access for NZ fruit and vegetable exports at $250 million (present value), if growers cannot access products needed to meet new standards.

Scenario 3: Deterring investment in novel methane inhibitors

- We use the case of a novel methane inhibitor to illustrate how regulatory delays affect companies' decisions to apply for approval/registration in New Zealand.
- Expediting approvals could deliver $43-183 million in benefits (present value) through earlier and lower cost emissions reductions
- Findings illustrate how regulatory delays can prevent products from reaching markets entirely, not just delay their arrival.

Not a cost-benefit analysis

Our scenarios are hypotheticals, intended to gauge the scale of benefits from regulatory improvements or, equivalently, the value at risk from the status quo.

We have not examined exactly how regulation or regulatory procedures would have to change to improve on the status quo nor the costs associated with change.

Contents

1. Purpose and scope

We have been asked to assess the potential economic impacts of improved access to agricultural and horticultural products that are regulated by HSNO and ACVM.

The jumping off point is a cluster of issues raised in submissions to the Ministry for Regulation's Agricultural and Horticultural Products Regulatory Review:

- Fragmented regulatory system; duplication; lack of coordination.
- Regulatory system not responsive/adaptive to changes.
- Products not being processed fast enough; restricting access to products needed for optimum productivity.

1.1. Not a cost-benefit analysis

Our task is to scope the size of potential effects, using scenarios, without specifying exactly how regulation or regulatory procedures would have to change to achieve them.

That is, we are not modelling exactly what the Review will end up recommending, because that is not yet known.

Accordingly, this is not a cost-benefit analysis. Our assessment is about the size of the prize from three indicative examples of possible regulatory improvements or, equivalently, the value at risk from the status quo.

The results of the analysis must be read with the understanding that **we are not measuring net benefits of regulatory change**. A formal cost-benefit analysis of the full swathe of costs and benefits from the Review's recommendations is an important option for further research.

1.2. Focus on faster access and market value

We focus on the benefits of faster access to new products, as a short-hand for improved access. This is a convenient approach. It should not be read as an assumption that faster approval is always better approval; benefits of speed need to be balanced against risk and cost. But it is an appropriate approach in current circumstances where there are long queues for consideration of regulatory approval.

Our measures of benefits are, for the most part, measures of market value i.e. volumes of things produced with explicit prices in traded markets.

However, much of the purpose and benefits of regulation – of food safety and of environmental protection – is to safeguard non-market value. Given time, budget and information constraints, we do not estimate changes to these important non-market impacts.

1.3. High-level assessment based on what-ifs

Our analysis provides high-level estimates of benefits from faster access to agricultural and horticultural products. We take a lot of liberties by referring to regulated products, processes and users as if they are a single or a simple thing.

We are mindful that HSNO and ACVM regulate a complex system, from a risk perspective and an industry and product perspective.

In an ideal world, we would delve into more detail than we have. However, that has not been possible for reasons discussed in the next section.

1.4. Approach to scenario development

What we have done is to focus on measuring costs and risks from existing delays and hypothesise about reducing delays to infer benefits from regulatory change.

The scenarios we use to do this are presented in section 3 and the details of those scenarios are the subject of the rest of the report that follows.

In general, we have erred on the side of simplicity when constructing our scenarios. Our scenarios adopt baselines that, for the most part, assume a continuation of the recent past in terms of e.g. economic activity (levels), regulatory delay, and rate of application for new product approvals.

We have avoided speculating about the future size of agricultural industries and the downstream effects that improved productivity could have on overall national income or material living standards.

The reason we adopt this approach is that we want the link between our assumptions and our results to be as clear as possible.

Our analyses and results are scenarios – a series of what-if assessments. If we add to those what-ifs a series of other assumptions – such as the relative rate of growth of livestock agriculture versus fruit production versus forestry – we would only muddy the waters. It would be harder for readers to discern the extent to which our analysis reflects our assumptions around regulatory processes versus our assumptions about land use change and export demand growth.

This does mean that our analysis and results are apt, on balance, to err on the low side in terms of benefits from improved access to agricultural and horticultural products. We think that is appropriate under the circumstances.

2. Context

Prior research provides some examples about the value of agricultural and horticultural products. Some of this is very useful context. However, the evidence base for assessing the economic value of new products for New Zealand is patchy.

Industry studies illustrate overall economic significance

NZIER (2019) assessed the contribution of crop protection to New Zealand industry in 2018 was between $7.5 billion and $11.4 billion. KPMG (2021) assessed the contribution of animal health products in 2020 at $12 billion.

These economic contribution studies help illustrate that the economic value of these products is much greater than, say, the simple sum of their sales (although the same can be said for any products in any industry).

The economic contribution numbers in the NZIER and KPMG assessments are interesting, but they are an extreme account of the contribution of agricultural and horticultural products that are based on lost productivity if these products disappeared and were not replaced by anything else.

Our analysis differs in that it focusses more on what could be, rather than what is, and it looks at additional value from new products and uses, rather than the average value of existing products and uses.

Few studies estimate incremental importance of products

NZIER (2019) did also assess the economic impact of delays in regulatory approvals for new crop protection products. They hypothesise that the cost of a one-year delay could be between $7 million and $70 million (present valued sum over 10 years).[1]

Other examples of research that had similar objectives to ours are the analyses that were produced by NZIER (2020) and Sapere (Davies and Barton, 2021) on the value to horticultural producers of access to hydrogen cyanimide. Those studies considered the effects on yields and orchard incomes of having to use alternative products and methods to manage bud-break – i.e. the incremental value of those products.

Decisions have been made to continue to permit the use of hydrogen cyanimide products, for now. But this example provides concrete evidence of the reliance that some producers can have on a particular product and the losses they face if a product is phased out without a new product to replace it. The analysis in Davies and Barton (2021) suggests that hydrogen

[1] We are not entirely sure how this estimate compares to our assessments in this report. The basis for NZIER's numbers is not completely clear.

cyanimide has boosted kiwifruit output by around 10% annually, approximately $220 million in a single year, circa 2019.[2]

Overseas studies are more comprehensive

Overseas, there have been several studies of the effects of reducing reliance on pesticides and adopting alternative methods of pest control. Bremmer et al (2021) used case studies of several different crops in different EU countries to estimate the impacts on yields and incomes of reducing pesticide use in accordance with the Green Deal Targets. They found impacts that included a 0.3% yield reduction per percentage reduction in pesticide use for apples and a 0.4% yield reduction per percentage reduction in pesticide use for tomatoes.

A related analysis of the EU Farm to Fork Strategy, by Bremmer et al (2023), looked in detail at how greenhouse production in the Netherlands could adapt to the likely outcome of reduced access to crop protection products. The analysis catalogues the range of crop pests controlled with chemicals and assesses the prospects for continued access to those chemicals and alternatives. They do not *per se* estimate cost of reduced access to active ingredients but they do assess the risk to production and prices and suggest that costs of production will rise.

Decent NZ evidence on costs but not incremental benefits

There are few similarly detailed estimates for New Zealand that would allow us to estimate incremental economic effects of reduced access to existing products, risks of not being able to access replacement products or new and better products; and by extension the benefits of accessing replacement products or new products.

Studies of the costs of weeds, for example, illustrate that negative impacts on yields are potentially large ($1.7 billion in 2014 according to Saunders et al, 2017), crop- and climate-dependent, and apt to get bigger over time as resistance develops (Goldson et al, 2015; Hume, 2024) and weeds spread to new areas. But these studies do not venture to estimate the incremental net benefits of control[3] or new products that might more cost-effectively control these weeds relative to existing methods.

Similarly, Nimmo-Bell (2009, 2021) has collated a range of estimates of the costs of pest control, including expenditure on control, which is very useful context but does not assess incremental changes in costs over time or prospects for improvements in future. The latest estimate is that the cost of pests in 2020 was $9.2 billion.

[2] These are broad orders of magnitude comparing the central estimates in Davies and Barton (2021) with our estimates of kiwifruit gross output in March year 2020 ($1.83 billion). Davies and Barton (2021) are not entirely clear on the time period that their numbers relate to, but the latest year in their kiwifruit production data is for the 2019/2020 season.

[3] An exception to this observation is the case of bio-controls where there has been very useful estimates of the efficacy and economic benefits of pest control measures e.g. Fowler et al (2016,2024).

Long run returns to R&D suggest large benefits from new products

At a more general level, we know that R&D in agriculture very often delivers large benefits – with median social rates of return of 12% and many new methods and products producing returns that are multiples of that (Rao et al, 2020).

We cannot be sure that the successes of the past will repeat in the future. But these numbers do tell us not to be surprised by analysis that proposes large benefits from accelerating access to new products and processes.

Furthermore, the academic literature on returns to R&D in agriculture emphasises that benefits accrue gradually over time and are heavily influenced by the rate of adoption and efforts to promote adoption – or extension as it is referred to in agriculture.

Important pieces of the puzzle are missing

The above research provides some helpful information: the value of novel products (R&D), the costs that might be avoided with improved products, and the gains we have seen from existing products.

Unfortunately, they don't provide a sufficient basis for rigorous assessment of the potential size of benefits from changes to regulatory arrangements in New Zealand that might accelerate access to new agricultural and horticultural products.

Ideally we could assess the typical rate of arrival of new products or compounds by product type (herbicide, pesticide, vaccine etc) and use (ground crops, pipfruit, sheep etc) and the typical yield or growth improvements associated with such new products – including the extent to which new products replace existing products that are declining in effectiveness or need to be phased out for toxicity or risk-related reasons.

However, there is insufficient readily available information for us to follow that approach. And our time is far too short to collect such information from scratch.

Thus, we arrive at using three illustrative scenarios to assess the potential benefits of improved regulatory approval processes.

3. Scenarios

In conjunction with the Ministry for Regulation we have drawn up three indicative scenarios, described below. The three scenarios capture different aspects of the risks or costs imposed by impeded access to new products. We start with a very general scenario, and then move to more specific scenarios.

The first scenario considers costs of delay overall and on average across all industries and products. This is our most general scenario and assumes business as usual in all respects except changes to regulatory delays.

The second scenario addresses the possibility of a break in business as usual. It analyses the possibility of a serious shock to export demand for horticulture products – something that producers in New Zealand have been concerned about for some time.

The third scenario delves into a specific type of product – a novel methane inhibitor. This scenario principally assesses, by way of example, the effects of delays on companies deciding to join the regulatory queue altogether.

3.1. Overview of scenarios

Scenario 1: Delayed diffusion of innovation

We examine the effects of reducing regulatory approval times by half, for all products and industries.

The pipeline of new agrichemicals and animal health products helps to maintain productivity and promises improvements.

Slowing the rate of arrival of new products raises two slightly different risks

i. production or profitability decline from where they are now

ii. producers miss out on opportunities to boost production or profits.

Yields or production can go down, without new products, for reasons that include

- gradual loss of effectiveness due to e.g. pests or weeds developing resistance
- new product standards (private and public) that discourage the use of the products or mean paying a premium for alternative production technologies.

In this general scenario, we do not specify precisely which channels these benefits come through. Rather, we make a general assessment of the implied value in new applications and the benefits of bringing that value forward.

Scenario 2: Loss of horticultural market access to EU

We use the EU as a case study because the EU has a history of stringent domestic regulations of agricultural chemicals and is considering more stringent regulations in future which could spill over into equivalent requirements of New Zealand and others' exports to the EU.

An example of this is the EU maximum residue limits (MRL) for pesticides. These have been more stringent than in most other parts of the world and have included even more stringent requirements implemented by importers (private standards).

In the late 2000s, New Zealand pip fruit growers established a commercial advantage in selling to the EU by reducing pesticide residues (Kaye-Blake and Zuccollo, 2012).

There is some concern that this comparative advantage could be undermined by a combination of new regulations, private standards, and access to chemicals that can be used without increasing residues.

As we understand it, due to delays in approving new horticultural products, some horticulture producers are now limited to just one or two relatively 'toxic' pesticides that are accepted by EU regulators as being safe.

This presents a risk that these legacy chemicals could fall out of favour with EU regulators before new replacement ones are approved. Should this occur, New Zealand horticultural exporters could temporarily lose access to the important EU market.

In the extreme, a ban on some agricultural chemicals in the EU could mean a complete loss of access for exporters to the EU market, which makes up around 15% of fruit and vegetable exports from New Zealand.

We present scenarios for the effects of increased trade barriers into the EU for fruit and vegetables, due to new agrichemical use regulations in the EU and their application to imports.

We then weigh those effects against the likelihood of this occurring and present a result for the value at risk from reduced access to new products.

Scenario 3: Delayed access to novel methane inhibitors

We examine the effect of regulatory delays on the introduction of feed additives and similar products for reducing greenhouse gas emissions.

The search for cost-effective methods to reduce livestock methane emissions has been going on for many years. Arguably, the absence of such measures has impeded progress on reducing both agricultural emissions and New Zealand's mitigation efforts more generally.

Overseas, feed additives – referred to as methane inhibitors – have become available that have been shown to be effective at significantly reducing ruminant methane emissions. The cost of these additives is not prohibitive, and it appears they do not harm the animals or materially affect productivity.

There has, however, been limited uptake so far because of limited commercial or policy incentives to use them and because the products are relatively new. We acknowledge that these incentives could change over time should agricultural emissions pricing occur and/or overseas buyers/consumers start applying greater pressure on agricultural producers to show emissions reductions.

There are practical impediments to the use of methane inhibitors in New Zealand. The main one is that animals need to be dosed daily or more than once daily. For a large proportion of New Zealand livestock that isn't feasible, or at least the cost would be prohibitive (for now).

Another potential reason they are not available is that, for now, there is limited incentive for farmers to buy them if they were available and there is limited incentive for companies to make them available, seeing as the demand isn't there.

It is plausible that regulatory cost is one of the impediments that has prevented the breaking of that loop.

Companies that want to sell inhibitors in New Zealand face a potentially lengthy delay between applying to introduce the product and being able to sell their product and getting a critical mass of customers to start making a return on product development costs.

Even if a product has already been marketed in other countries, companies must invest upfront in developing the product for sale in New Zealand. This includes both commercial investigations and preparing materials for regulatory processes e.g.

- testing the efficacy of the product in New Zealand conditions (field trials)
- testing for residues of any active compounds in animal products e.g. milk
- gathering data on potential environment effects.

The cost of product development can be substantial. It is likely to vary significantly depending on the product formulation and whether it has been widely researched or used in other countries, but we understand from a small selection of industry case studies that a reasonable ball-park estimate is that it will fall in a range of $1 million to $4 million.

Delays in regulatory approvals can impact these sorts of investments in product development. A company that is considering an investment will judge its value on the expected returns it gets from day one. Each year without any return is a loss that will be counted against the investment.

The fact that demand[4] and regulatory approval are not guaranteed, means that companies will also require a premium to compensate them for risk.

[4] Demand risk in this case consists of policy-related risks, the risk that the product may not perform as expected in NZ conditions, as well as the more general problem that other suppliers might enter the market with new products.

Furthermore, the uptake of a new product is likely to be gradual. So even when the product is approved it may be some years before the company is making a reasonable rate of return.

Bringing these considerations together, it is easy to see that regulatory delay can be an important impediment to product development in New Zealand – potentially to the point of preventing it entirely.

Though this scenario focusses specifically on potential impediments to the sale of methane inhibitors, the logic applies more generally to any investment in developing new agricultural and horticultural products for the New Zealand market. Regulatory costs, including delay, can have visible and invisible effects, respectively:

- delaying benefits from new products undergoing approval
- preventing application for approval in the first place.

We measure the impacts of regulatory delay in terms of the market value of marginal reductions in greenhouse gas emissions.

3.2. Approach to quantifying the scenarios

We assess the three scenarios using bespoke simulation models accompanied by extensive sensitivity analysis. Bespoke models are necessary because each simulation is very different in nature in terms of product, industry and market coverage, precluding the use of a single generic modelling framework.

The simulation models are mainly static – extrapolating from existing conditions. The exception to this is where dynamics are indispensable to the question at hand: regulatory application and approval. In that case, we measure changes over time.

Our default evaluation period is 20 years, and, for simplicity, we assume that if regulation and regulatory approval processes were changed they would be changed at the beginning of 2025.

All values presented are in real terms (inflation adjusted). We also report present-valued benefits where lower weight is placed on benefits in the future, to account for greater societal concern about imminent impacts relative to impacts in the far future. For these weights we mostly use a discount rate of 8% per year as suggested by the Treasury for discounting commercial impacts. Where the benefits are considered part of long-term public benefits we use a 2% discount rate.[5]

We have not assessed wider economic impacts – beyond the sectors or situations we are analysing – in our scenarios. In principle, this means we are understating benefits. However, we are of the view that measuring downstream impacts would provide little additional insight, given that these are only scenarios, but would add a raft of additional assumptions and other complications.

[5] Treasury Circular 2024/15: Updated Public Sector Discount Rates for Cost Benefit Analysis.

4. Delayed diffusion of innovation

4.1. Simulation set-up

Revealed value in applications for regulatory approval

The fact that companies have applied for regulatory approvals tells us something about the value of those products.

For example, consider a company that is willing to invest $3 million in product development and regulatory approval. Conventional analysis of investment decisions suggests that expected returns are multiples of $3 million. That means the investing company expects a market need and a benefit to farmers and growers from buying their products that will return multiples of $3 million.

We examine the benefits of faster regulatory approvals by inferring the market value of new products from assumptions about product development costs inclusive of regulatory approval costs.

Further, we can calculate the effects of the new products on users (money value of yield improvement, loss avoidance or cost reduction) by assuming they are equal to the seller's benefits (return on investment).[6]

Assumptions required to run the simulations

The assumptions required to undertake this analysis are:

- product development costs[7]
- expected rate of uptake of new products
- investors' required rates of return
- investors' time horizon for evaluating the investment
- time taken to obtain regulatory approval[8]

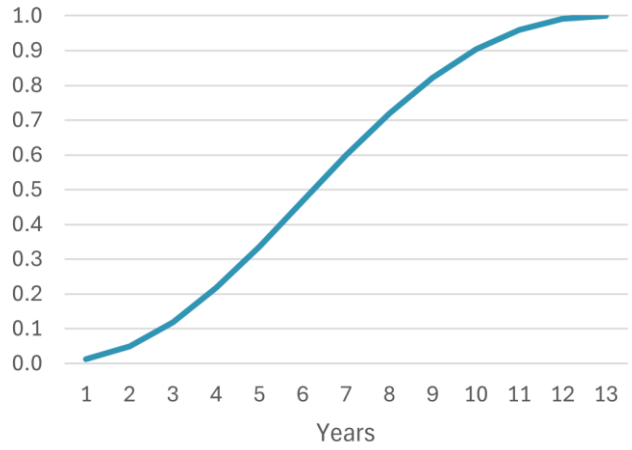
[6] We motivate this assumption three ways. First, buyers need a cost-benefit ratio that is greater than 1 before they can be persuaded to change to a new product. Second, benefits to users will vary. Some benefits will be very low and users will be very price sensitive. Others will have a very high willingness to pay e.g. because they have had a pest event and/or a rapid build-up of resistance on their property. So sellers trade off selling at a high price to some users versus selling to many users at a lower price. Third, it is conventional to assume, with no other information, that benefits are shared equally between producers and consumers.

[7] Includes regulatory approval costs but excludes costs of primary research and new overheads/capital expenditure. That is, for this analysis we assume that no new factories or labs need to be built – that all new products are either imported or produced with existing production facilities.

[8] This is the only time delay we include that will affect investment decisions. That is, for simplicity, we ignore the time path of product development expenditure other than regulatory costs.

- the number of applications being made for regulatory approval
- the time saving achievable for regulatory approvals.

FIGURE 1: ASSUMED RATE OF UPTAKE OF NEW PRODUCTS
Share of maximum market uptake/benefits of new products



Numbers used in the analysis

For all products we assume that

- the investment evaluation time horizon is 10 years[9]
- rate of uptake of new products follows the profile in Figure 1[10]
- regulatory approval times[11] can be halved
- the required rate of return is 15%.

Product development costs, time to obtain regulatory approval and required rates of return are assumed to increase by complexity of regulatory approval and extent of testing required for commercial development. As a starting point:

1) Products that contain novel active ingredients, are new to New Zealand and require **complex** regulatory approvals[12]

[9] This aligns with the standard time periods for data secrecy (so limits on competition) for novel products. Shorter payback periods might be used for new uses that do not receive 10 years of data protection, but rather receive a shortened 5 year data protection period. However we use a single 10 year period for project evaluation for simplicity.
[10] This is the time path of benefits from agricultural R&D, after new methods and products enter the market and up to the point where benefits typically peak, suggested by Alston et al (2011,2023).
[11] A halving of the time from first applying and joining a queue. Not the time taken to process an application once the processing is underway.
[12] Assumed to capture costs for ACVM applications in category A1 and EPA/HSNO category C.

a) $2 million for product development[13]

b) average of 5 years to obtain regulatory approval[14]

c) 6 applications are made per year, on average[15]

2) Products that are new to New Zealand, but do not contain novel active ingredients, and are **difficult** to scrutinise and prepare regulatory applications[16]

a) $1 million for product development

b) average of 23 months to obtain regulatory approval[17]

c) 7 applications are made per year on average[18]

3) for all **other** products[19]

a) $100,000 dollars for product development/approval

b) average of 5 months to obtain regulatory approval[20]

c) 140 applications are made per year.

[13] Approximate mid-point of a selection of case studies. The case studies are confidential but a public study by Kelly et al (2024) concurs.
[14] We assume that HSNO approvals are the key determinant of this value. This value reflects the Ministry of Regulation's assessment of current delays of 67 months, as at 30 September 2024, based on EPA data. We have rounded that figure down, because we understand increased resources are expected to reduce time taken to obtain approval. By rough comparison, the mean time to obtain approval for registration of ACVM category A1 products was between 200 and 300 days, on average in 2024 (2024 ACVM Workshop presentations (July)).
[15] Average annual volumes of A1 ACVM applications, past 3 years.
[16] Assumed to capture costs for ACVM applications in category A2 and EPA/HSNO categories A and B.
[17] Average of median wait times for approval of HSNO category A and B applications, weighted by the number of applications processed, in 2023.
[18] Average annual volumes of A2 ACVM applications, past 3 years.
[19] ACVM B1, B2 and new use (C4-C8) applications. Excluding research and R&D categories.
[20] Application-weighted average of wait times for approval for HSNO category A applications (only 8% of this category) and ACVM approvals in categories B1, B2, and C4 to C8 (average over agricultural chemicals and veterinary medicine applications).

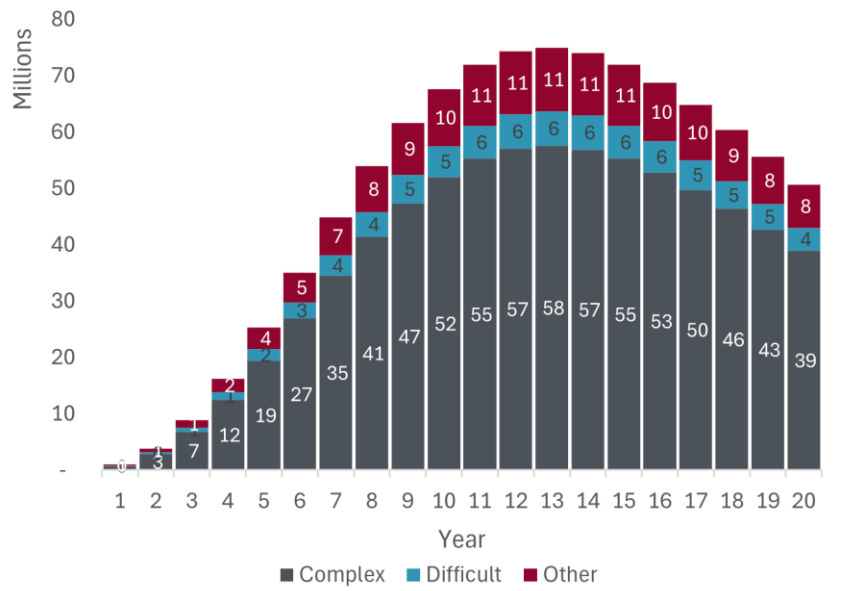
4.2. Baseline value of products in regulatory pipeline

Using these assumptions, we can estimate a benchmark market value of products submitted for regulatory approval, by backward engineering commercial break-even net cashflow (also user benefits) in the last year of the investment evaluation period and inferring cashflows in earlier periods using our assumed take-up rates and discount rates.

This produces a projected flow of value as shown in Figure 2. This is an estimate of the cumulative amount of new value in agricultural and horticultural products applying for approval in one year.

FIGURE 2: SIMULATED TIME PATH OF BENEFITS FROM 1 YEAR'S APPROVAL OF APPLICATIONS

Real millions of dollars. Not adjusted for timing of approval

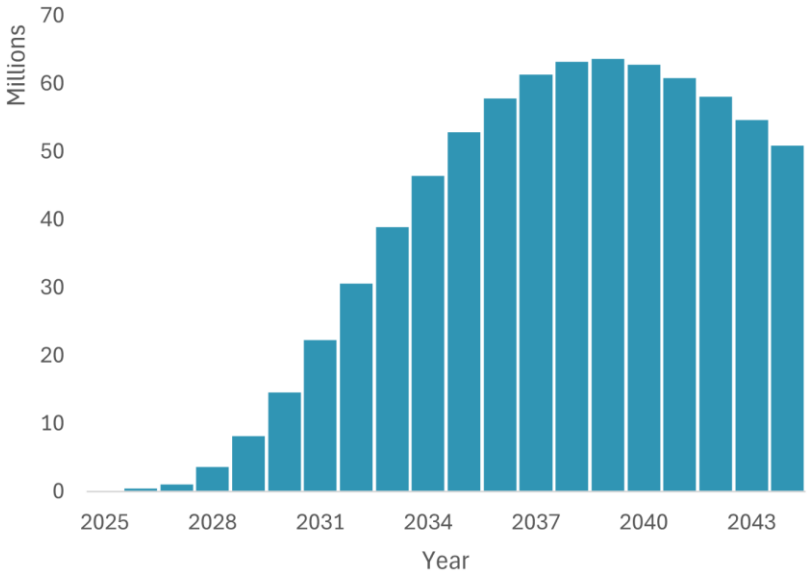


Each year new products come to market, and we assume they follow the same path in terms of timing of uptake and value for users stemming from one year of approvals, as shown in Figure 2. Combining 20 years' worth of approvals we get a net value for future use benefits – over and above costs paid for new products – that rises to $990 million in year 20, ignoring costs of delay. The total sum of value over the 20 years equates to a present valued net-benefit of $2.7 billion.

4.3. Benefits from reducing regulatory delay

Delays in regulatory approvals move this benefit stream forward in time. Assuming that approval times can be halved, the difference in timing of benefits yields a gain that is roughly equal to the use benefits of a single year's set of approvals (see Figure 3).

FIGURE 3: TIME PATH OF BENEFITS FROM BRINGING APPROVALS FORWARD BY A YEAR
Real millions of dollars, not discounted



On an annual basis the benefits peak at $64 million after 15 years and then trail off. That peak benefit equates to a **0.4% increase in agricultural GDP**.[21] This is, as it happens, equivalent to a little more than one year of agricultural GDP growth based on the average of the past 20 years.

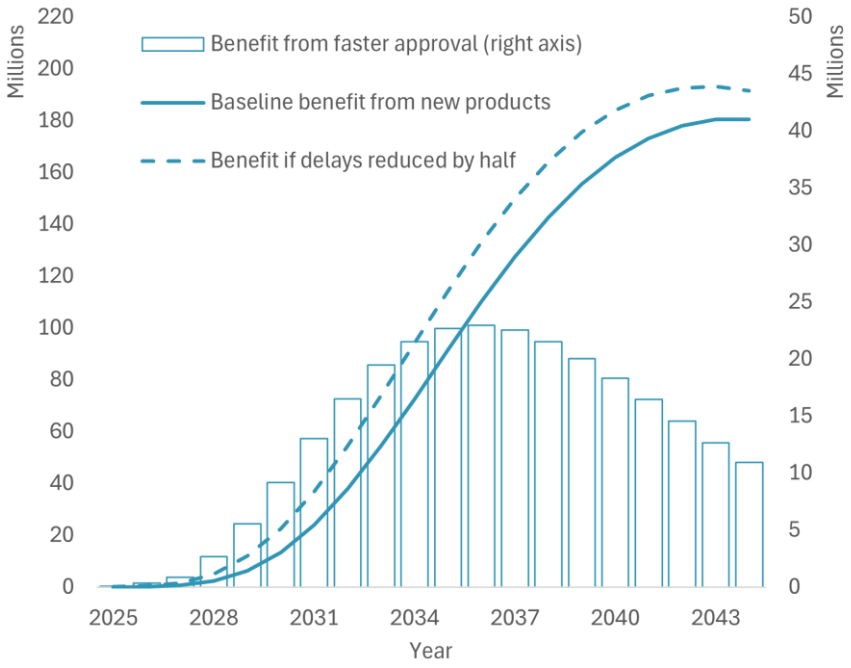
In present value terms (see Figure 4), the annual benefits peak in year 10 ($23 million) and **the sum of benefits over 20 years, discounted by 8%, is $272 million.**

In practice, delays could worsen without intervention. If that was taken into account, the benefits of addressing delays would keep increasing.

For the sake of clarity, recall that we do not consider here the resource costs of regulatory changes that might bring about a halving in approval times. As noted earlier, this report is not a cost-benefit analysis.

[21] This is based on extrapolating current price agriculture GDP in 2022 by the compound annual average rate of growth in constant price (real) GDP for the past 20 years.

FIGURE 4: BENEFITS OF HALVING REGULATORY DELAY, OVER 20 YEARS



5. Loss of horticultural market access

5.1. Estimating the size of potential trade effects

Quantifying the potential increase in trade barriers

To simulate the effects of EU market access barriers we need to assess the potential size of *de facto* trade barriers that could emerge.

A recent research article estimated that MRLs for pesticides have had a material effect on trade in fruit and vegetables (Hejazi et al, 2022). On average, trade declined by 8% when MRLs were 10% more stringent in an importing country compared to the exporting country.[22] This effect is equivalent to a tariff of 13%.[23]

Hejazi et al (2022) also find evidence for larger negative effects for trade into the EU, ostensibly because EU regulations are more stringent to begin with.[24] The effect sizes they find are equivalent to an approximate 20 percentage point tariff increase for a reduction of average MRLs in the EU in the order of 5-10%.

This provides a useful basis for gauging the scale of effects that agricultural chemical regulations can have on trade, beyond simply bans or other intractable barriers.[25] It points to rapidly increasing costs of trade with increasing regulatory stringency.

We use a 20% increase in trade costs as a starting point for our scenarios of possible and plausible impacts on trade if there is a change in regulation in the EU and insufficient capacity to respond to that quickly within New Zealand.

We have not linked this directly to changes in MRLs. MRLs are only one aspect of chemical regulations, and, in our view, there is good reason to believe that the estimates in Hejazi et al (2022) are likely to be capturing both MRL effects and other aspects of agrichemical import measures.[26]

Furthermore, our analysis is illustrative only. For example, we simulate the impact of a uniform percentage increase in trade costs for all countries exporting to the EU. This is a significant

[22] The measure of stringency used in the paper is highly non-linear – applying much higher weight to large differences than small differences. The measure is the exponential of the difference between exporting country MRL and importing country MRL as a percentage of importing country MRL.
[23] Assuming a trade elasticity of -6 for horticultural products (Fontagne et al, 2022).
[24] In the paper this is presented as impacts specific to trade between the EU and the US.
[25] This is important as a complete exclusion of trade is unlikely. Even very stringent regulation is unlikely to eliminate trade as some producers will be able to adapt to meet the regulations. For example, producers with very high productivity can wear the costs of adaptation, even if it means a reduction in their productivity.
[26] Also, it was impractical, in this assignment, to run sensible scenarios for changes in actual MRLs. It would have required making judgements about future changes in MRLs in all major exporting and importing markets.

simplification, albeit one chosen after considering whether the effects on New Zealand exporters would be likely to be smaller or larger than for exporters in other countries.

On the one hand, New Zealand may be at a greater disadvantage, relative to other countries, because small market size and a relatively slow approvals process means new products are likely to be slower to arrive here. On the other hand, New Zealand government and industry are better equipped than most to minimise the effects of new regulations. New Zealand's food safety systems, regulatory knowledge, diplomatic service and industry capability are very good compared to many other countries.

So, on balance, we simply assume a uniform shock to trade costs.

Simulating the impacts of cost increases

We simulate impacts of increased trade costs using data on fruit trade and vegetable trade for 163 countries in 2019.[27]

We use a large data set so that we can take account of the huge number of substitution possibilities that exist for exporters and importers if one market becomes harder to trade with. That is, as one market becomes harder to export to, alternative markets are found, albeit at a cost in terms of lower average export prices.

We estimate general equilibrium trade impacts using a model of changes in trade shares in response to changes in trade costs.[28]

This approach allows us to estimate impacts of increases in trade costs on trade flows and prices and incomes taking account of global adjustment in trade flows between all countries.[29]

A key assumption needed in the simulations is the degree of responsiveness of trade to changes in trade costs (the trade elasticity of substitution). Our starting point is a single value of -6, which is an estimate of the change in trade in response to changes in trade costs over long periods of time – years to decades – allowing for structural changes in supply chains and logistics.[30]

Our principal interest is in costs of adjustment over relatively short periods of time – 1 to 3 years. There is good evidence that trade elasticities are smaller (in absolute terms) in the shorter run (Boehm et al, 2020; Anderson and Yotov, 2020) – that trade adjusts more over the long run than in the short run. So, alongside the scenarios with a trade elasticity of -6 we

[27] This is the most recent large-scale dataset we have available that is not perturbed by COVID effects. Though it is a bit old, it still captures the key market shares in terms consumption and production and imports and exports.
[28] Presented in Head and Mayer (2014) and introduced by Dekle et al (2007)
[29] Hence the result is presented as a general equilibrium result – although only in respect of trade. It holds constant many aspects of the economy one would expect to change in a full general equilibrium model of trade.
[30] Average of product-specific trade elasticities for fruit and vegetables in Table 5 of Fontagne et al (2022).

examine effects on trade with an elasticity of -3.[31] Using both elasticities also helps to demonstrate the sensitivity of results to this key assumption.[32]

For simplicity, we conduct our simulations using aggregate trade for fruit and, separately, for vegetables; rather than simulations product-by-product. Implicitly, we assume no land use change or changes in investment and employment in these or other industries. We look only at trade and income changes.

We test for the effects of 3 different sized shocks to trade costs:

- 20% increase (low)
- 40% increase (medium)
- 80% increase (high).

Results of trade cost scenarios

The table below summarises the effects of increased trade costs on New Zealand exports of fruit and vegetables to the EU, New Zealand fruit and vegetable exports in total, and the gross income of the fruit and vegetable growing industries i.e. sales to domestic and international customers.

Trade cost changes of up 80% get close to an almost complete ban on exports to the EU. Of course, it does not require a ban to foreclose trade. Producers will move to other markets if trade becomes too costly.

In all scenarios the fall in the value of total exports from New Zealand is smaller (in dollars) than the reduction in exports to the EU, because of substitution to other markets (including an increase in sales volumes at home).

Shifting sales to other markets does come with a cost in terms of accepting lower prices. The impact on sector sales is thus a mixture of lower prices and lower volumes.

The **total effect of the simulated trade cost increase ranges from -$116 million for a 20% trade cost increase in the very short run, through to a cost of -$345 million for a more severe 80% trade cost increase that persists for several years**. Those are values for a single year in 2019 dollars. These costs are relative to total New Zealand exports of fruit ($270 million) and vegetables ($90 million) to the EU.

[31] Also, in our model we limit wage flexibility (so-called "sticky wages"), consistent with most models of shorter run adjustment. So, impacts fall most heavily on owners/profits.
[32] There are many competing estimates of trade elasticities and reason to believe some estimates are overstated (Simonovska and Waugh, 2014). A value of -3 aligns with long run results for recent estimates of elasticities of agricultural product trade from analysis of firm level data in Lashkaripour and Lugovskyy (2023).

TABLE 1: HYPOTHETICAL IMPACT ON THE FRUIT AND VEGETABLE SECTORS
2019 prices. Effects of increased trade costs due to changes in EU product regulations.

Trade elasticity	Trade cost increase	Sector	Value of exports to EU	Value of exports total	Change in sector sales (NZDm)
-6	20%	Fruit	-49%	-6%	-132
		Vegetables	-66%	-11%	-62
-6	40%	Fruit	-75%	-9%	-203
		Vegetables	-86%	-14%	-81
-6	80%	Fruit	-94%	-11%	-254
		Vegetables	-97%	-16%	-91
-3	20%	Fruit	-27%	-3%	-76
		Vegetables	-42%	-7%	-39
-3	40%	Fruit	-47%	-6%	-131
		Vegetables	-63%	-10%	-60
-3	80%	Fruit	-70%	-9%	-196
		Vegetables	-83%	-13%	-78

5.2. Implications for agrichemical regulation

The costs outlined in Table 1 provide a means of gauging the order of magnitude of costs that could be incurred if producers are not able to adopt products or practices that meet new market access regulations or demands of private standards.

Although the costs are hypothetical scenarios, they are matched by real world observations of the impacts of fruit and vegetable product regulations. For example, Hejazi et al (2022, p.2) say:

> *US exports of apples and pears to the European Union (EU) have declined by 80% and 97%, respectively, between 2008 and 2018 partially due to stringent residue limits revised by the EU in 2008.*

The question then is whether such costs could be avoided if local producers could access alternative methods of e.g. pest control and if they could, the extent to which delayed regulatory approvals could get in the way.

Simulation set-up

In the second part of this scenario we quantify the risk of substantial regulatory delays that prevent industry adjustments. To do this we assume:

- significant regulatory changes occur in the EU every 4 years, on average[33], and there is a one in two chance that new product regulations are put in place,[34]
- the new regulations have an equal chance of being equivalent to a 20%, 40% or 80% increase in trade costs
- regulatory delay means that New Zealand growers, who have been preparing for this eventuality, face reduced access to the EU market for a period of two years, on average but potentially for longer[35], while
- in a counterfactual scenario, we assume that market access is not impeded
- loss of market access will only happen once in 20 years – that learning from bad experience will ensure it only happens once.

Simulated value at risk

The chart below presents the simulated results of potential costs. The variation in cost size is a function of how large the trade cost shock is and how long it persists. In the extreme cases new products are several years to arrive and consequently the trade cost shock lasts several years. We see this as unlikely.

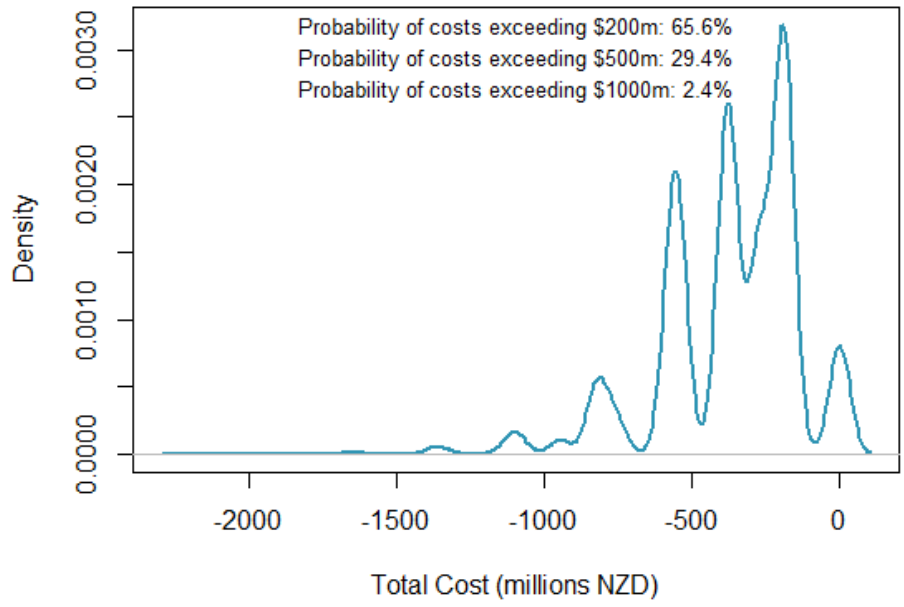
In the simulation the mean time for loss of reduced access is 22 months.

The most likely outcome, in this simulation, is that important potentially trade restricting regulatory changes do occur at least once in the next 20 years i.e. few simulations yield a potential net cost of 0.

Overall, **the mean probability weighted cost of not being able to respond to EU regulatory changes for horticultural chemicals is $375 million over 20 years (present value $250 million)**.

[33] This aligns with the frequency that EU common agricultural policies are reset. However, we assume that the event of regulatory change is random.
[34] We assume a 50:50 chance on the grounds that we have seen significant changes twice in the past ten years, albeit the latter changes (e.g. Farm to Fork strategy) look like they are being unwound before having an effect on trade barriers.
[35] We use a lognormal distribution (mean 0.5 and standard deviation 0.5) to capture uncertainty about length of the time period that market access is affected.

FIGURE 5: DISTRIBUTION OF SIMULATED COSTS



6. Delayed access to novel inhibitors

6.1. Simulation set-up and assumptions

We model the probability that a company would invest in developing a methane inhibitor for the New Zealand market, given expectations of the time taken for the product to be approved.

Given uncertainty about the cost-effectiveness of a novel inhibitor, we simulate the probability of market entry using a range of plausible values. Our base assumptions are

- product development costs are expected to be between $1 million and $4 million[36]
- companies require a rate of return between 12% and 20% annually[37]
- the product is marketed to dairy farmers only
- the unit cost of the inhibitor is between $50 and $150 per cow per year[38]
- the inhibitor is sold at a mark-up over unit cost that maximises profits, up to 50%[39]
- the inhibitor reduces methane emissions of treated cows by between 10% and 50%[40]
- product development work is expected to take 2 years, excluding the time taken for regulatory approvals.[41]

We model the potential uptake of the inhibitor by farmers using a version of the well-known S-curve of adoption of new products and technologies over time that includes adjustments for the faster uptake for more cost-effectiveness technologies (see Appendix for details).

The maximum market size for the product is uncertain given e.g. scope for competing methane mitigation technologies over time. We consider values of 500,000, 1 million, 2 million and 4 million mature cows, roughly equal to 10%, 20%, 40% and 80% of the current herd of mature dairy cows.

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[36] This is assumed to be inclusive of the cost of submitting and speaking to regulatory applications. We model uncertainty about development costs using log normal distribution (mean 14.5, standard deviation 0.3). This yields a range of roughly $1 million to $4 million. The central value in this range is $2 million, supported by an estimate from Kelly et al (2024).
[37] This range is informed by research on typical hurdle rates (Jagannathan et al, 2011; Melolinna et al, 2018; Edwards and Lane, 2021). We model uncertainty using a triangle distribution centred on 0.15.
[38] We start from numbers cited for Bovaer What Can We Really Expect from Elanco's New Bovaer®? | Dairy Herd and account for uncertainty about costs of novel inhibitor using a uniform distribution with costs that are +/-50%.
[39] The simulation accounts for price sensitivity of uptake, which limits the size of the mark-up.
[40] This reflects the potential reductions achieved with Bovaer in non-pasture environments with a range of, +/-20%. Some inhibitors have been shown to be even more effective than this but there are indications that this increased effectiveness can carry costs from lower animal weight. We model uncertainty about this number using a uniform distribution.
[41] Rounded down from 2.5 estimated in Kelly et al (2024).

Details around future climate policy and the size of farmer incentives to adopt the inhibitor are uncertain. We consider two possibilities. One is that incentives are linked to emissions prices that are expected to rise over time from $70 per CO_2 equivalent tonne of emissions to $270 per tonne. The other is that there is a fixed subsidy of $100 per cow that is expected to be constant over time.[42]

6.2. Benefits of reducing regulatory delay

We find that regulatory delays can impede market entry. Although they are a relatively minor consideration compared to expectations about policy and incentives and market size.

Figure 6 and Figure 7 illustrate. The first of the figures shows probability of market entry if the potential market is large (80% of the current herd). It shows that regulatory approval delays only impede market entry a little if uptake incentives are fixed and not at all when they are rising over time with emissions prices. If the market is large and pay offs from entry are growing over time, the cost of delay is not large enough to have much effect in terms of deterring market entry.

Figure 7 shows that with a much smaller market potential (10% of current herd), delay can have a significant effect on profitability and therefore market entry. But the size of the effect depends on whether incentives to buy the new product are rising over time or not.

The fixed incentive of $100 per cow is a stronger incentive for adopting the inhibitor in the short run. But this potential for encouraging early adoption also means market entry decisions are more sensitive to expectations about regulatory delays.

When incentive rates are fixed, adoption occurs at the same rate regardless of when the product enters the market. So, delays are costly. A regulatory delay of 4 years causes the probability of market entry (0.16) to fall by around 20 percentage points compared to a regulatory delay of 2 years (probability of market entry 0.38). When incentive rates are rising over time, delays are not quite so costly.

Benefits of reducing regulatory delay are a combination of social benefits from reducing the cost of emissions reductions, by increasing the probability of market entry, plus the gains from bringing net benefits of emissions reductions forward in time.

[42] At the low end, a 10% reduction in emissions per cow is an average of 231kg of CO_2e per year. This means a fixed incentive of $400 per tonne of CO_2e reduced. At the high end of effectiveness in our scenarios the incentive amounts to $87 per tonne of CO_2e. At the mid-point the incentive amounts to $144 per tonne.

FIGURE 6: PROBABILITY OF MARKET ENTRY, LARGE POTENTIAL MARKET

Assumed market potential is 4 million cows. Chart shows how probability of market entry changes depending on delays in regulatory approval.

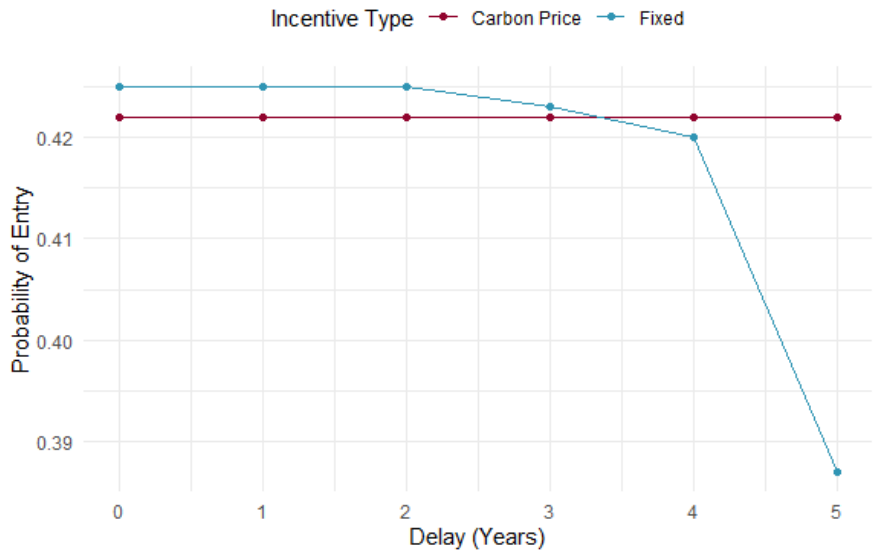
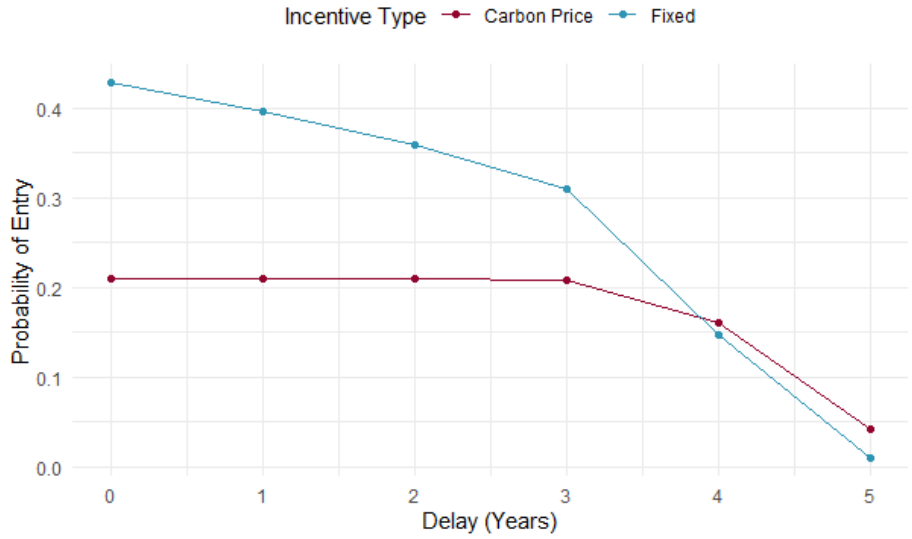


FIGURE 7: PROBABILITY OF MARKET ENTRY, SMALL POTENTIAL MARKET

Assumed market potential is 500,000 cows. Chart shows how probability of market entry changes depending on delays in regulatory approval.

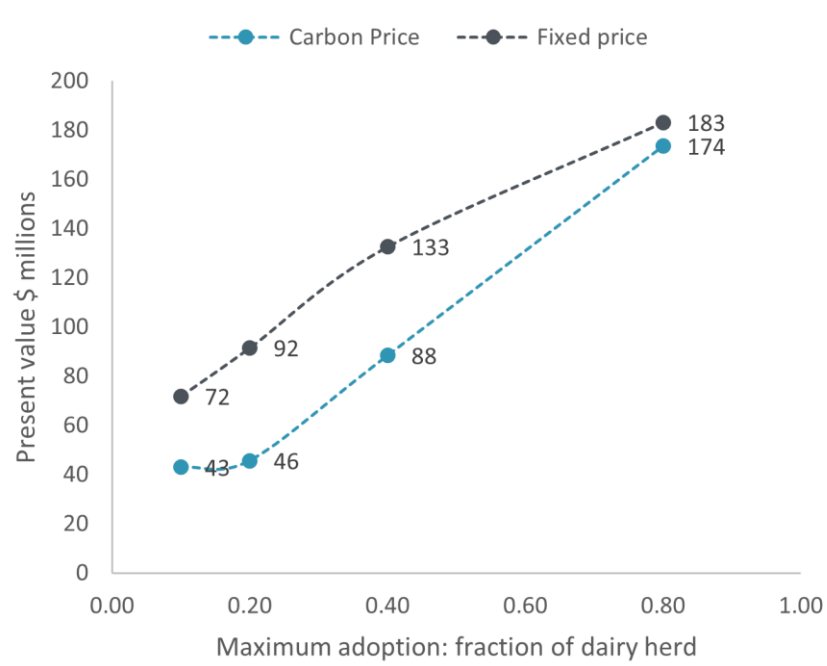


The **benefits of reducing regulatory delay range from $43 million (net present value) to $183 million**, depending on the potential maximum market penetration and policy incentive

used to encourage adoption. The range of results is presented in Figure 8. These are for a 2 year reduction in regulatory approval times from 4 years to 2 years.[43]

The benefits of expedited approvals have been valued using the expected reduction in methane emissions times the shadow cost of emissions proposed by the Treasury[44] less the incentive payment[45], in the case of the fixed price incentive, and less the payments made to the supplier in the case of the carbon price incentive. The benefits are then summarised as the present value sum over 20 years discounted at 2%.[46]

FIGURE 8: BENEFITS FROM EXPEDITED APPROVAL OF NOVEL INHIBITORS
Present valued benefit from change in cost of reducing emissions



Our estimates of benefits are only illustrative. We have not, for example, taken account of the effects of new cost-effective methane mitigations on policy, carbon budget settings, market demand, and hence emissions prices. We have also not allowed for actions that could be taken to accelerate adoption i.e. to catch up on the effects of delays.[47]

[43] We have used a slightly shorter baseline approval time of 4 years, compared to the 5 years used for complex approvals in scenario 1. This is on the grounds that a new cost-effective inhibitor is more likely to be expedited than other products due to potentially high public interest relative to many other agricultural and horticultural products.
[44] Table 1 in the Treasury guidance on Assessing climate change and environmental impacts in the CBAx tool - October 2024.
[45] Inclusive of a 20% uplift for deadweight loss of taxation.
[46] Public project discount rate recommended by NZ Treasury.
[47] Although such actions could be taken regardless of regulatory delays it is reasonable to expect that policy action/ambition will be a function of the level of agricultural emissions and a tightening carbon budget over time. That being so, a dynamic endogenous policy response could result in catch up.

Appendix: additional method details

Scenario 1: Effect of delays on diffusion

Assumed rates of uptake of new products

In scenario 1 we use a gamma lag function to approximate the lifecycle of new products from gradual adoption through to decline in effectiveness or replacement by better technologies.

Alston et al (2023) argue that this sort of function provides a useful approximation to what has been observed in markets for new agricultural products over many decades.

The function we use defines a set of weights over time (w_t) that describe how benefits of new products accrue and depreciate:

$$w_t = (t - g + 1)^{\frac{\delta}{1-\delta}} . \lambda^{t-g}$$

In our application the time variable (t) is integer years from product approval. The parameter g is years of gestation, which we set to 0 because we are focus on adoption.

We set the parameter values to $\lambda = 0.75$ and $\delta = 0.8$ selected to align with peak adoption and benefits occurring 13 years after commercial release. This aligns with observations in Alston et al (2023) of benefits peaking after 24 years from first investment and, within that time period, research and development times taking 10 to 15 years.

This uptake function is a simplification intended to capture average rates of uptake. In practice, some products take longer to penetrate such as new plant varieties that take time to grow and mature (e.g. vines). Other products such as pesticides might be taken up much more quickly if there is a pressing need for them.

Returns on investment in developing new products

We infer expected commercial returns on investing in a new product using the following equations.

The first is for the maximum net revenue (π_H) at the end of the investment evaluation period/horizon (H) inclusive of time taken to obtain approval (q), given a required rate of return (r), initial nominal investment in product development (D) and expected rate of uptake of product (u_t):

$$\pi_H = \frac{D(1+r)^q}{\sum_t^{H-q} u_t \left(\frac{1}{(1+r)^t}\right)}$$

This maximum net revenue is the value required to ensure the investment breaks even, conditional on the required rate of return.

The uptake value u_t is a function of the weights (w_t) described above with maximum time to full uptake adjusted for time taken to obtain approval:

$$u_t = \frac{w_t}{w_{T-q}}$$

The assumed time path of net revenue is then a function of the rate of uptake (assuming a constant average price over time in real terms):

$$\pi_t = \pi_H . u_t$$

User benefits as a function of investor net revenue

The benefits to users are assumed to be proportional to commercial net profit and persist beyond an investors time horizon. The consumer benefit horizon (T) is assumed to be 20 years to align with our horizon for assessing benefits from improved access to products.

$$b_t = \frac{w_t}{w_T}\theta\pi_H$$

Our default assumption is that user benefits are equal to supplier benefits, so $\theta = 1$.

The above equations are used to depict expected benefits from the average product, with parameters varying by complexity of regulatory approval (as described in the body of the report).

To assess the overall benefits (B_t) of multiple approvals we simply multiply the assessed benefits of a representative product (b_{it}) by the expected number of products submitted for approval (N_i), where i indexes category of complexity for regulatory approval i.e.

$$B_t = \sum_i b_{it} . N_{it}$$

That yields a profile of user benefits for a given years' worth of applications.

Combining multiple years of new products

To assess benefits of new products over 20 years we take the sequence of benefits from a single year of products over 20 years (i.e. B_t above) and, indexing each element in the sequence by j=1,2,... 20, we add them so that total benefits (T) from multiple years accumulate as in:

$$T_t = \sum_{j=1}^{t} B_j . N_{t-j+1}$$

Scenario 2: Loss of horticultural market access

Model of changes in trade as a function of changes in trade costs

The model we use to assess the effects of changes in trade costs is a simplified model that relates changes in trade shares ($\hat{s}_{ij}$) to changes in trade costs ($\hat{\tau}_{ij}$) and changes in factory or farm gate incomes/output ($\hat{Y}_i$) using two related equations founded in structural gravity

models. The indices i and j denote origins (sellers) and destinations (buyers). The trade share values denote the share of a destination's expenditure that is spent on products from a given origin. All change ($\widehat{\ }$) variables are ratios of new values to baseline values.

The first equation explains changes in trade shares as a function of changes in output, changes in trade costs, baseline/initial trade shares (s_{ij}) and trade elasticity of substitution (ϵ):

$$\hat{s}_{ij} = \frac{\left(\hat{Y}_i \hat{t}_{ij}\right)^{\epsilon}}{\sum_i s_{ij}\left(\hat{Y}_j \hat{t}_{ij}\right)^{\epsilon}}$$

The second equation, based on a market clearing, explains changes in the value of sellers' output/incomes in terms of initial (baseline) output (Y_i), changes in trade shares, initial trade shares, initial (baseline) destination expenditure (X_j) and changes in destination output ($\hat{Y}_j$).

$$\hat{Y}_i = \frac{1}{Y_i}\sum_j \hat{s}_{ij} s_{ij} \hat{Y}_j X_j$$

We simulate the effects of changes in trade costs by imposing a change in trade costs. We then iterate over changes trade shares and changes in incomes until we find a solution that satisfies both equations.

For further details and background around this approach to measuring the effects of trade costs see Head and Mayer (2014).

Scenario 3: Delayed access to a novel inhibitor

Model of the rate of adoption of the new technology

We assume a path of diffusion, or adoption, of the new technology from the time that the technology is ready to be used to the time that maximum uptake has been achieved. We apply a version of the Bass (1969, 2004) model which is a mathematical expression of the well-known S-curve of adoption of new products and technologies over time. The model is:

$$a_t = p(m - a_{t-1}) + q\left(\frac{a_{t-1}}{m}\right)(m - a_{t-1})\left(1 + e\frac{c}{I}\right) + a_{t-1}$$

Where adoption at a given point in time (a_t, fraction of the maximum market uptake) is a function of:

- the rate of uptake by innovators (p, a parameter controlling rate of acceleration of adoption)
- maximum uptake (m, fraction of the market, default = 0.99)
- the rate of uptake by imitators (m, default value 0.38)
- elasticity of uptake (e, default value 1) in response to changes in incentives
- incentives measured by the private cost benefit ratio of (c/I , default value 1).

This diffusion model has the effect of assuming that all projects' adoption rates follow an 'S-curve' to maximum uptake – growing slowly at first, then rising rapidly and then levelling off as adoption approaches its assumed maximum.

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