Potential costs of regulatory changes for gene technology

Economic assessments of an MBIE proposal

NZIER report to Organics Aotearoa New Zealand

November 2024

About NZIER

New Zealand Institute of Economic Research (NZIER) is an independent, not-for-profit economic consultancy that has been informing and encouraging debate on issues affecting Aotearoa New Zealand, for more than 65 years.

Our core values of independence and promoting better outcomes for all New Zealanders are the driving force behind why we exist and how we work today. We aim to help our clients and members make better business and policy decisions and provide valuable insights and leadership on important public issues affecting our future.

We are unique in that we reinvest our returns into public good research for the betterment of Aotearoa New Zealand.

Our expert team is based in Auckland and Wellington and operates across all sectors of the New Zealand economy. They combine their sector knowledge with the application of robust economic logic, models and data and understanding of the linkages between government and business to help our clients and tackle complex issues.

Authorship

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Key points

- The Ministry of Business, Innovation & Employment (MBIE) has provided public information about proposed changes in regulations for gene technology. The aim of the changes is to expand the use of gene technology in New Zealand.
- The proposal does not include a Regulatory Impact Statement, economic impact assessment or cost-benefit analysis. As a result, it is focused on potential benefits without regard for potential costs or challenges.
- Organics Aotearoa New Zealand (OANZ) engaged NZIER to consider the regulatory changes from an economic perspective, and we have focused on possible costs of the changes and the challenges of achieving the expected benefits.
- NZIER investigated the value of New Zealand's brand and different market messages used in export markets.
  - Risk-averse exporters are likely to be concerned about the release of GMOs into the market. They may be worried about the risk to their price premiums in markets such as the European Union and Japan.
  - There may be risks to the supply chains that New Zealand supplies. While New Zealand producers do not typically supply direct to consumers, some of the available evidence reviewed in this report suggests that there exists a consumer price premium for GE-free food.
- The quantitative analysis we have been able to conduct with limited time and resources suggests that environmental release of GMOs in New Zealand could reduce exports from the primary sector by up to $10 billion to $20 billion annually. We note that estimated impacts are based on price premiums at the consumer level, and that other research suggests there would be no impact. Given the disparities in findings and the potential size of the impact, a more complete economic assessment is warranted.
- We also considered the potential challenges in achieving economic benefits. The actual experience of gene technology worldwide provides some indication of potential challenges. A small number of crops are used for low-value purposes: up to 90 percent of GM crops are used for animal feed. Many products, even those that are fully scientifically developed and not subject to additional regulation, such as non-browning mushrooms, fail to be successfully commercialised. The difficulties of commercialising scientific innovation are well researched and well understood.
- The proposed changes raise several issues, including connections between law and economics, the treatment of risk and reward, and the relevance to New Zealand's economy. These issues do not appear to have been considered in the publicly available material.
- NZIER hopes that this report contributes to a wider, evidence-based discussion of potential impacts of gene technology, one that learns from prior experience in addressing so-called 'wicked' problems through engagement and interdisciplinary discussions. We need more evidence before making potentially irreversible decisions.

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1 Introduction

Organics Aotearoa New Zealand (OANZ), the organisation representing the interests of the organics agri-food sector in New Zealand, commissioned NZIER to provide economic analysis for proposed regulatory changes, focusing on potential negative impacts on the country's exports.

The proposed regulatory changes have been described by the Ministry of Business, Innovation & Employment (MBIE) in a 'Gene technology media pack' (Ministry of Business, Innovation & Employment, 2024). The proposed regime is intended to increase the use of gene technology. An overview from the media pack is reproduced in Figure 1. Some products of gene technology would no longer be regulated. Other products would be regulated using a risk-based approach. The regime would consider risks to the health and safety of people and risks to the environment, but would not consider economic costs and benefits.

The MBIE document is focused on the potential benefits. Its second sentence is, 'Gene technology (also known as genetic engineering or genetic modification) is a powerful tool available to scientists that has the potential to deliver enormous benefits for New Zealand.' Shortly thereafter, it states, 'With updated rules our scientists can make advances in healthcare, adapt to climate change, protect our unique environment, lift our agricultural productivity and boost exports.'

This NZIER report does not take issue with these statements. Instead, it points out that regulatory changes are likely to have both benefits *and costs*, and seeks to provide information about potential costs using available economic data and standard economic methods. The focus of this report is the potential impacts of the proposed changes on agriculture and tourism; the medical and environmental impacts that are included in the regulatory changes are not considered.

From the outset, NZIER would emphasise that the issues raised by OANZ merit more investigation that we have been able to provide. Primary research on the value of different market messages and positionings to New Zealand's export markets can inform the regulatory discussion. Some of that work has already been done, as discussed in this report. Ideally, additional research would consider the impact of market message by consumer segment, product, and country in a way that provides good coverage of New Zealand's export sales. Market messages would include New Zealand's clean, green image; organic agriculture; GE-free; and made with gene technology. The research would consider not just food products but other exports, such as tourism. While there is evidence to support a quantitative analysis – evidence that we discuss below – additional data would improve the analysis. This view is backed up by Caradus (2023a):

> *An issue that needs to be debated and resolved in NZ is the attitudinal positions*

Some abbreviations in this report

GE – genetic engineering

GM – genetic modification

GMO – genetically modified organisms

GE-free – produced without genetic engineering

GMO-free – not containing genetically modified organisms

taken by processing and marketing industries associated with products from pastoral agriculture. This would involve quantifying the comparative value of organic produce and the GM free status of the country across different market segments.

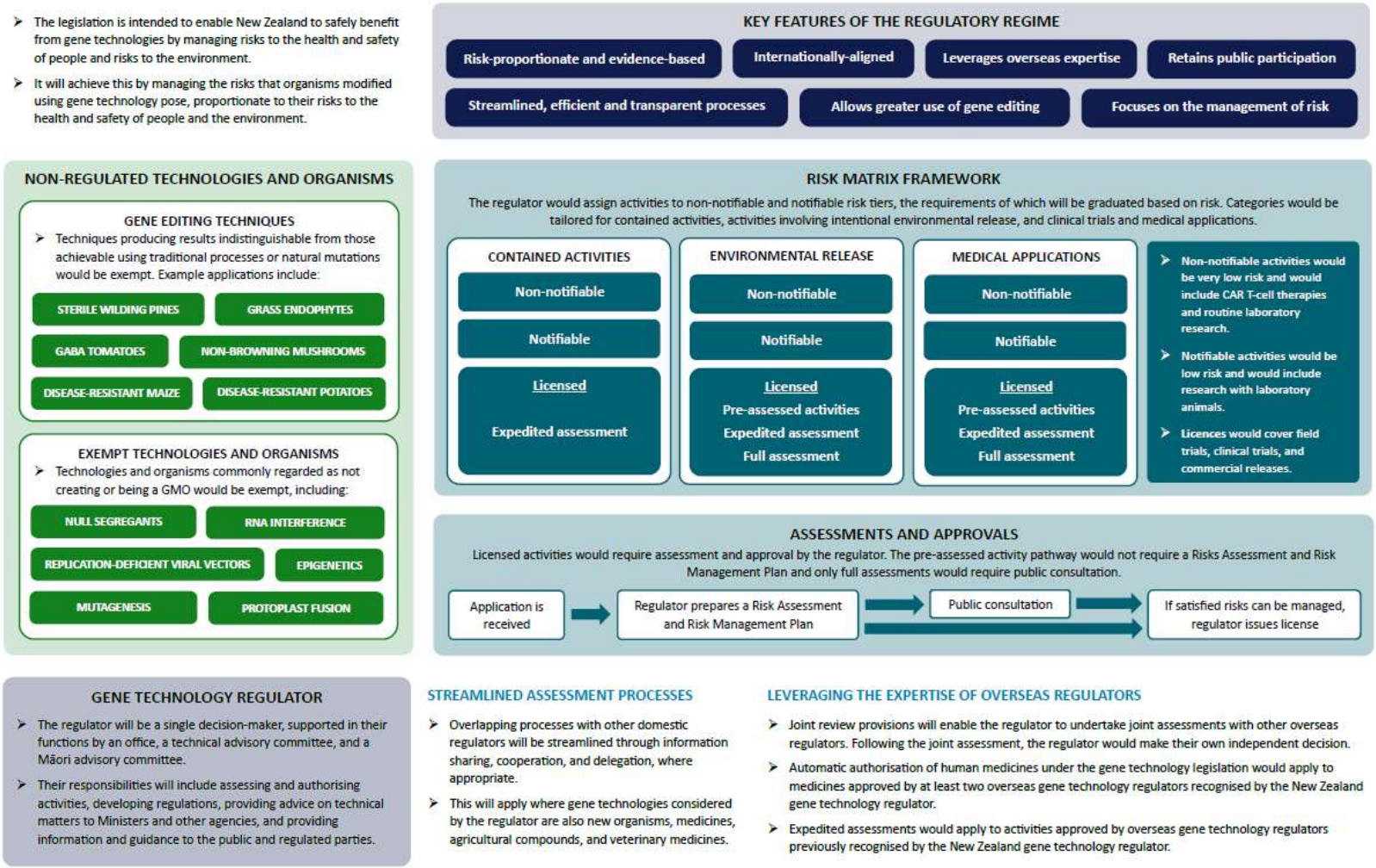
These processors and marketers are closer to the agri-food market than researchers working on scientific discoveries, and they are directly affected by any regulatory change.

This report has three main sections. The first section provides quantitative analysis of the value of different market messages or positioning. The analysis gives some indication of the 'size of the prize' from good regulation. The second section considers the economics of innovation and the actual performance of selected gene technology innovations in the agri-food sector. The third section canvasses a number of economic issues that arise from the proposed regulatory changes. This section puts an economic lens over the changes to contribute our expertise to the discussion. Again, the aim is to contribute economic understanding to the discussion.

NZIER is aware that the regulation of gene technology is a contentious issue in New Zealand and elsewhere. It can be classified as a 'wicked problem' (Crowley & Head, 2017; Ooi & Husted, 2022): an ill-structured problem with no right answer, complex and interrelated, with uncertainties and multiple interpretations. The experience in New Zealand of the National Science Challenges has demonstrated the value of approaching wicked problems with engagement across the scientific, public and private sectors (Davenport, 2019; Gluckman, 2015; Ooi & Husted, 2022) and the importance of transdisciplinary (Gluckman & Kaiser, 2023). Therefore, with this report, we offer our expertise in economics to help broaden the understanding of the potential role of gene technology in New Zealand's economy.

Figure 1 Overview of the gene technology regulatory regime

- The legislation is intended to enable New Zealand to safely benefit from gene technologies by managing risks to the health and safety of people and risks to the environment.
- It will achieve this by managing the risks that organisms modified using gene technology pose, proportionate to their risks to the health and safety of people and the environment.



Source: MBIE (2024)

2 The value of New Zealand's brand

2.1 Researching the brand value

For this project, we searched for research on New Zealand's 'brand' in overseas markets, including the brand '100% Pure' and the more general 'clean, green image'. We also searched for quantitative work on the impacts of market perceptions around GMOs and organic production. The aim of the literature scan was to identify material that put a value on New Zealand's reputation in export markets.

These are topics in which we had some experience. We were aware of researchers who work in this area and added relevant items to our search results library. We performed citation searches on these items and identified further relevant material.

Our search was based on various combinations of keywords and phrases that included 'clean green image', '100% pure', 'organic', 'Non-GM', 'GM-free', 'New Zealand', 'brand', 'reputation' and 'value'. As searching is an iterative process, other keywords were introduced, including combining identified authors with keywords. Further citation searches were also undertaken on new material located. Reference lists were also scanned from items identified in the searches.

This included:

- Databases such as ABI-Inform, Repec, Te Puna, AgEcon and the Ebsco research databases
- Internet searches using Google Scholar and Google search engines
- Site-specific searches, e.g. Lincoln University, where we knew that work in the past had been done on this topic.

We used the Zotero reference tool to manage and organise the results.

2.2 The primary sector

New Zealand exported $54.6 billion in food and fibre sector products in the year to June 2024 (Ministry for Primary Industries, 2024). Some fraction of that export revenue is underpinned by perceptions about New Zealand: 'In 2008 a PwC survey found that more than 80 per cent of New Zealand exporters believe that New Zealand's clean green image is vital to their export profile' (Stewart, 2012).

There is little data on the value of the clean, green image to agri-food exports. One key reference is work by PA Consultants (2001), which appears to be the only attempt to put a dollar value on the clean, green image. They estimated that loss of that perception would reduce dairy exports by $241 million to $569 million (in 2000). Other estimates seem to focus on the value to tourism and the 100% Pure brand, about which more later.

We reviewed the literature to find research that estimated the value of different market perceptions or market messages for New Zealand exports. These perceptions and messages are called 'credence attributes' in the economic literature. They are things that people believe (the Latin *credere*, to believe) about products in the market but cannot easily test or experience themselves. For example, it is possible to taste a product and find that it is

sweet or salty; it is much more difficult to know for certain that it is environmentally friendly.

The credence attributes for primary exports that we investigated were:

- GM-free
- Organic production
- Organic and non-GMO (some studies cover non-GMO as a part of organic production)
- New Zealand's clean green image
- Production in New Zealand.

The primary source of data for these credence attributes was research by Lincoln University's Agribusiness and Economics Research Unit (AERU). Their work was conducted in several stages, including work funded by MBIE in the Maximising Export Returns (MER) programme and in the Our Land and Water (OLW) National Science Challenge (NSC). Conducting a series of overseas surveys, the researchers investigated the value of several credence attributes for different products, countries and market segments. They used a well-researched economic method of stated preference surveying (discrete choice modelling) to find the willingness to pay for these credence attributes.

2.2.1 Clean, green image

We did not find any research that put a value on the clean, green image as a credence attribute for New Zealand products, except for PA Consultants (2001). Neither Knight (2011) nor BERL and AERU (2003), which investigated the impact of GMOs on the clean, green image, estimated the value of that image. The AERU research programme did investigate credence attributes about 'NZ raised and processed' or 'Produced in NZ'. These market messages are broader than 'clean and green' or '100% Pure' but do give an indication of the special value of the New Zealand brand. Table 1 provides data from the literature, reporting the willingness to pay (WTP) or price premium that consumers would pay for the credence attribute for different products in different markets.

The average across the estimates is 59 percent. This figure suggests that New Zealand on average could be receiving a 59 percent higher price for its primary exports because of its country brand or image. Two key issues with this figure are:

- It is based on willingness to pay at the consumer level, not prices in commodity and ingredients markets that are important for New Zealand exports.
- It is unknown how attributes such as consistency and safety contribute to the 'produced in NZ' brand.

Table 1 Price premium for New Zealand-produced exports

From New Zealand-based research

Premium	Attribute	Product	Market, including consumer segment	Source
22%	NZ raised and processed	Ground beef	California, US	Tait et al. (2018a)
10%	NZ raised and processed	Top sirloin	California, US	Tait et al. (2018a)
11%	NZ raised and processed	Ribeye steak	California, US	Tait et al. (2018a)
45%	Produced in NZ	Sauvignon blanc	California, US	Tait et al. (2018c)
123%	Grown in NZ	Kiwifruit	Shanghai, PRC	Tait et al. (2018b)
143%	Produced in NZ	Yogurt	Shanghai, PRC	Tait et al. (2018d)
59%	**Average, NZ produced**			

Note: 'US' = United States; 'PRC' = People's Republic of China'.

2.2.2 GM-free

We investigated the credence attribute GM-free and variations. The price premiums collected from the literature are shown in Table 2. The table provides the price premium as a percentage of the base price of the product, the credence attribute evaluated, the product, and the country and consumer segment (if available). The price premium has a wide range, from 1% to 231%. A few averages have been calculated and presented at the bottom of the table. Some of the data provided is from research that investigated the 'organic production' credence attribute, but specified that GM-free was included in the organics attribute.

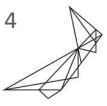
The focus was on New Zealand research and prices for New Zealand products. There is considerable international research on the willingness to pay for GM and non-GM food. We have not attempted to survey the entire literature. Driver et al. (2023) provided a useful review of the literature, although we do not know how complete it is.

These figures suggest that consumers' belief that New Zealand is GE-free creates a price premium for food and fibre exports of 24 percent and possibly more.

Table 2 Price premium for GM-free products

With a focus on New Zealand-based research

Premium	Attribute	Product	Market, including consumer segment	Source
Just GM-free, either product or feed				
14%	GMO-free	Ground beef	California, US	Tait et al. (2018a)
6%	GMO-free	Top sirloin	California, US	Tait et al. (2018a)
7%	GMO-free	Ribeye steak	California, US	Tait et al. (2018a)
96%	GE-free	Apples	'Conscious Consumers', California, US	AERU (2023) and Tait et al. (2022a), in Driver et al. (2023)
8%	GE-free	Apples	'Broad Considerations', California, US	AERU (2023) and Tait et al. (2022a), in Driver, et al. (2023)
17%	GMO-free	Beef tenderloin	'Animal Attentive', Beijing, PRC	AERU (2023) and Tait et al. (2022b), in Driver, et al. (2023)
11%	GMO-free	Beef tenderloin	'Cultural Consumer', Beijing, PRC	AERU (2023) and Tait et al. (2022b), in Driver, et al. (2023)
89%	GMO-free	Beef tenderloin	'Organic Oriented', Beijing, PRC	AERU (2023) and Tait et al. (2022b), in Driver, et al. (2023)
43%	GMO-free	Beef mince	'Cultural Consumer', UAE	AERU (2023) and Tait et al. (2022c), in Driver, et al. (2023)
7%	GMO-free	Beef mince	'Carbon Concerned', UAE	AERU (2023) and Tait et al. (2022c), in Driver, et al. (2023)
24%	GMO-free	Beef mince	'Feedlot Focused', UAE	AERU (2023) and Tait et al. (2022c), in Driver, et al. (2023)
9%	No GM Feed	Lamb leg	'Environmentally Engaged', UK	AERU (2023) and Tait et al. (2022e), in Driver, et al. (2023)
15%	No GM Feed	Lamb leg	'Natural Necessary', UK	AERU (2023) and Tait et al. (2022e), in Driver, et al. (2023)
13%	No GM Feed	Lamb leg	'Group 1', UK	Tait et al. (2020c), in Driver, et al. (2023)
10%	No GM Feed	Lamb leg	'Group 2', UK	Tait et al. (2020c), in Driver, et al. (2023)
15%	No GM Feed	Lamb leg	'Group 3', UK	Tait et al. (2020c), in Driver, et al. (2023)
Organics that included GM-free indication				
25%	Made with organic grapes (incl no GMOs)	Sauvignon blanc	California, US	Tait et al. (2018c)
31%	100% organic (incl no GMOs)	Sauvignon blanc	California, US	Tait et al. (2018c)
55%	Certified organic (incl GE-free)	Kiwifruit	Shanghai, PRC	Tait et al. (2018b)



Premium	Attribute	Product	Market, including consumer segment	Source
Grocery data				
15%	Labelled non-GMO	Apples	US	Grocery data, provided by OANZ
49%	Labelled non-GMO	Berries	US	Grocery data, provided by OANZ
9%	Labelled non-GMO	Carrots	US	Grocery data, provided by OANZ
143%	Labelled non-GMO	Cucumbers	US	Grocery data, provided by OANZ
1%	Labelled non-GMO	Grapes	US	Grocery data, provided by OANZ
176%	Labelled non-GMO	Potatoes	US	Grocery data, provided by OANZ
231%	Labelled non-GMO	Tomatoes	US	Grocery data, provided by OANZ
24%	**Average, GM-free only**			
26%	**Average, GM-free plus organics**			
42%	**Average, GM-free, organics, and supermarket data**			

Note: 'US' = United States; 'PRC' = People's Republic of China'; 'UAE' = United Arab Emirates; 'UK' = United Kingdom.

2.2.3 Certified organic and organic production

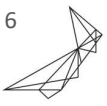
The literature we reviewed also assessed credence attributes for certified organic and organic production. We present those findings in Table 3. The exact description of organic production varies across the studies. As before, the table includes different products and market segments. The organic premium ranges from 5 percent to 116 percent.

The figures suggest that, on average, New Zealand could earn an extra 39 percent for products sold overseas as organic.

Table 3 Price premium for organic products from New Zealand

From New Zealand-based research

WTP	Attribute	Product	Market, including consumer segment	Source
23%	Organic	Ground beef	California, US	Tait et al. (2018a)
10%	Organic	Top sirloin	California, US	Tait et al. (2018a)
11%	Organic	Ribeye steak	California, US	Tait et al. (2018a)
25%	Made with organic grapes (incl no GMOs)	Sauvignon blanc	California, US	Tait et al. (2018c)
31%	100% organic (incl no GMOs)	Sauvignon blanc	California, US	Tait et al. (2018c)
55%	Certified organic (incl GE-free)	Kiwifruit	Shanghai, PRC	Tait et al. (2018b)
51%	Organic	Yogurt	Shanghai, PRC	Tait et al. (2018d)
88%	Organic production	Apples	'Conscious Consumers', California, US	AERU (2023) and Tait et al. (2022a), in Driver, et al. (2023)
17%	Organic production	Apples	'Broad Considerations', California, US	AERU (2023) and Tait et al. (2022a), in Driver, et al. (2023)
104%	Organic production	Apples	'Strong Preferences', California, US	AERU (2023) and Tait et al. (2022a), in Driver, et al. (2023)
14%	Organic production	Beef tenderloin	'Animal Attentive', Beijing, PRC	AERU (2023) and Tait et al. (2022b), in Driver, et al. (2023)
33%	Organic production	Beef tenderloin	'Cultural Consumer', Beijing, PRC	AERU (2023) and Tait et al. (2022b), in Driver, et al. (2023)
116%	Organic production	Beef tenderloin	'Organic Oriented', Beijing, PRC	AERU (2023) and Tait et al. (2022b), in Driver, et al. (2023)
78%	Organic production	Beef mince	'Cultural Consumer', UAE	AERU (2023) and Tait et al. (2022c), in Driver, et al. (2023)
11%	Organic production	Beef mince	'Carbon Concerned', UAE	AERU (2023) and Tait et al. (2022c), in Driver, et al. (2023)
7%	Organic	Kiwifruit	'Healthy Me, Healthy Environment', Japan	AERU (2023) and Tait et al. (2022d), in Driver, et al. (2023)
13%	Organic	Kiwifruit	'Broad Considerations - Taste Driven', Japan	AERU (2023) and Tait et al. (2022d), in Driver, et al. (2023)
25%	Organic	Kiwifruit	'Safety Focused', Japan	AERU (2023) and Tait et al. (2022d), in Driver, et al. (2023)
15%	Organic farming system	Lamb leg	'Environmentally Engaged', UK	AERU (2023) and Tait et al. (2022e), in Driver, et al. (2023)
5%	Organic farming system	Lamb leg	'Cultural Consumers', UK	AERU (2023) and Tait et al. (2022e), in Driver, et al. (2023)
20%	Organic production	UHT milk	'Broad Considerations', Beijing, PRC	AERU (2023) and Tait et al. (2022f), in Driver, et al. (2023)



WTP	Attribute	Product	Market, including consumer segment	Source
103%	Organic production	UHT milk	'Pasture Preferred', Beijing, PRC	AERU (2023) and Tait et al. (2022f), in Driver, et al. (2023)
24%	Organic production	UHT milk	'Broad Considerations', Shanghai, PRC	AERU (2023) and Tait et al. (2022f), in Driver, et al. (2023)
33%	Organic production	UHT milk	'Pasture Preferred', Shanghai, PRC	AERU (2023) and Tait et al. (2022f), in Driver, et al. (2023)
81%	Organic production	UHT milk	'Strong Preferences', Shanghai, PRC	AERU (2023) and Tait et al. (2022f), in Driver, et al. (2023)
8%	100% Organic Production	Sauvignon blanc	'Organic Origin', California, US	AERU (2023) and Tait et al. (2022g), in Driver, et al. (2023)
39%	**Average, organics**			

Note: 'US' = United States; 'PRC' = People's Republic of China'; 'UAE' = United Arab Emirates; 'UK' = United Kingdom.

2.2.4 Impact on New Zealand exports

The exact economic impact on export revenue of the proposed regulatory changes regarding gene technology is unknown. The data presented above provide information for estimating the value of different market messages or credence attributes, although we stress that more primary and secondary research is warranted. An estimate of the value of market messages starts from the value of New Zealand's food and fibre exports in the year to June 2024, which was $54.6 billion (Ministry for Primary Industries, 2024).

- If the value of the New Zealand brand, including the clean, green image, is a 59 percent premium over basic world prices, then a loss of that premium would be worth $20.3 billion annually from food and fibre exports.[1]
- If market perceptions that New Zealand is GE-free creates a premium of 24 percent over basic world prices, the loss of that perception would be worth $10.6 billion annually from food and fibre exports.[2]
- The organic premium of 39 percent suggests that New Zealand could earn an additional $21.0 billion in export revenue if all food and fibre products were organic. There would also be impacts on production and costs to consider (Saunders & Emanuelsson, 2005).

These figures are based on willingness to pay at the consumer level, not prices in commodity and ingredients markets that are important for New Zealand exports, so they may overstate impacts on the country's export revenues.

2.3 Tourism industry

The 100% Pure brand was originally a tourism brand, but has come to support the New Zealand brand and exports more widely (Patil, 2019; Smol et al., 2019). The PA Consultants (2001) report provided an initial look at the potential impact of release of GMOs on tourism

[1] The premium currently exists, so the calculation is (1 – 1/1.59) * $54.6 billion.

[2] Similarly, the calculation is (1 – 1/1.24) * $54.6 billion.

in New Zealand. Several sources and studies since then have discussed the value of 100% Pure, but generally without providing an updated estimate of the potential value. Kaefer (2016a, 2016b) discussed doctoral research on the topic, and the only economic estimates provided are from Insch (2011) and PA Consultants (2001). The former cited two numbers: Interbrand (2005) estimated the value of New Zealand's tourism brand at US$13.6 billion, and BrandFinance (Anholt-GMI, 2005) estimated the value of 'brand New Zealand' at US$102 billion. In addition, to our knowledge, none of this research has been from the perspective of te ao Māori or kaupapa Māori.

The PA Consultants (2001) study surveyed incoming tourists from what were then the top five visitor markets, making up almost 85 percent of tourist visits. It asked tourists about their responses to a degradation in the environmental perceptions of New Zealand. It found that tourists would shorten their stays in New Zealand by up to 80 percent, leading to a loss in revenue of 66.3 percent. The data from the report and calculation of loss are shown in Table 4. We would urge caution in using these figures to estimate the economic impact of regulatory changes because of concern over the robustness of the report's method. However, we also underline that no other estimate of New Zealand's clean, green image is available, even more than 20 years after the original study.

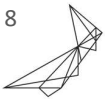
Table 4 Impacts on tourism of losing New Zealand's clean, green image

Based on a survey of international visitors

Metric	Australia	United States	United Kingdom	Japan	Korea	Total
Total expenditure (NZ$ million)	907	807	693	703	108	3,218
Current average length of stay (days)	18.44	39.08	37.18	34.98	42.16	
Average length of stay under worsened perceptions (days)	8.9	7.72	13.56	10.14	12	
Proportion: potential stay/current stay	0.4826	0.1975	0.3647	0.2899	0.2846	
Potential loss: (change in stay * current spend) (NZ$ million)	-469	-648	-440	-499	-77.3	-2,133
Total loss in tourism revenue						66.3%

Source: PA Consultants (2001)

COVID-19 has affected international tourism. The estimated impact of changing environmental perceptions on tourism receipts depends on the baseline used. Since this report considers the potential impact on tourism sometime in the future, we can adopt the position that tourism will have recovered from its setbacks by then. In 2019, before COVID-



19 and its impacts on international tourism, international tourism expenditure in New Zealand was $17.2 billion (Statistics NZ, 2019).

The final step is to understand the link between environmental perceptions of New Zealand and environmental release of GMOs. One possibility, expressed by Knight et al. (2013) based on face-to-face surveys with 515 overseas tourists at Auckland airport, is that 'it is highly unlikely that New Zealand's image as a tourist destination would suffer if GM plants were introduced' (see also Knight, 2011). Another possibility is supported by BERL and AERU (2003), which found in a survey of international visitors that 23 percent stated that a release of GMOs would worsen their image of the New Zealand environment. In addition, 'just over one quarter stated that they would be less inclined to purchase New Zealand products or holidays' (BERL & AERU, 2003).

The link between GMOs and environmental perceptions can also be pieced together based on New Zealand research that may also reflect attitudes of international visitors. Milfont et al. (2020) pointed out that there are different combinations of attitudes that make up segments of the New Zealand population (see Figure 2 in the Appendix, page 28). For most, a clean and green attitude was important to their identity. Coyle & Fairweather (2005) explored New Zealand's clean and green image as a 'place myth'. They also counterposed a narrative by the government of biotechnology innovation as an alternative place myth. They reported that for some people, the clean and green myth anchors a reluctance to take up biotechnology. If this holds for international visitors – that an element of the clean, green image is a lack of GMOs in the environment – then environmental release of organisms created with gene technology would be expected to harm environmental perceptions.

The research does show that the clean, green image and the 100% Pure brand are valuable to New Zealand. One remaining question is whether and to what extent they could be harmed by environmental release of GMOs. There is research to suggest no impact and research to suggest harm from a release of GMOs. In addition, if there is harm, there is little research on which to base an economic calculation. Because there are more questions than answers, we would urge further investigation.

3 Economic lessons from past gene technology innovations

3.1 Innovation as a complex, dynamic process

Gene technology has been used to create commercial agri-food products for 30 years. These products provide an evidence base for understanding the challenges of commercialisation. NZIER has experience in the economics of innovation (NZIER, 2024) and can use its understanding to draw lessons from that evidence base. Its framework places innovation in a complex context that includes competition for limited resources, competition from other technologies and innovations, consideration of demand-pull and supply-push factors, interactions with partners and users, and change over time in a dynamic process of adoption.

The next section reviews products that have not been successfully commercialised, in order to investigate the economic drivers affecting gene technology products. There are several successful commercial GM crops being used extensively around the world; we have not reviewed them here. The MBIE material supporting the proposed regulatory changes is

clear about potential benefits. The aim here is to provide more information about the challenges of achieving those benefits.

3.2 Discontinued, unsuccessful and non-commercial products

3.2.1 Non-browning mushrooms

The media pack from MBIE on the proposed regulatory changes (Ministry of Business, Innovation & Employment, 2024) lists non-browning mushrooms as one of the 'Environmental / Agriculture examples' of gene technology. Non-browning mushrooms were created in 2015 at Pennsylvania State University in the US (Waltz, 2016). At the time, US officials were reportedly 'very excited' by the new mushroom. The US Department of Agriculture (USDA) determined that the non-browning mushrooms, produced with CRISPR technology, were not consider genetically modified and therefore not subject to any additional regulation. In 2015, the University filed a patent application, and in 2016, the scientist involved was 'mulling over whether to start a company to commercialize his modified mushroom' (Waltz, 2016).

In 2021, an expert suggested that non-browning mushrooms 'are expected to be launched in the near future' (Patron & Price, 2021). By 2023, however, non-browning mushrooms were not commercially available in Australia or New Zealand (Massel, 2023). In 2024, the product is approved but not commercialised (Polidoros et al., 2024), and publications are still relying on the 2016 *Nature* article (Waltz, 2016) as the source of information on non-browning mushrooms (e.g., Polidoros et al., 2024).

This example provides two insights. First, regulatory barriers cannot be blamed for the lack of commercialisation because the USDA explicitly exempted the innovation from special regulation as a genetically modified food (the usual food regulations would still apply). Second, a scientifically successful innovation, even one that generates as much expectation as non-browning mushrooms over nearly 10 years, may not lead to a commercial product. Expectations and excitement are not the same as a commercially viable business plan and road to market.

3.2.2 FLAVR SAVR tomato

The FLAVR SAVR tomato was the first commercial GMO food crop (Bruening & Lyons, 2000). 'The research and marketing efforts that produced the FLAVR SAVR tomato resulted in scientific success, a temporary sales success, and then commercial demise' (Bruening & Lyons, 2000, p. 6). 'Demand for the FLAVR SAVR tomato was high and remained high, but the product was never profitable' (Bruening & Lyons, 2000, p. 7). Martineau (2001) provided an inside account of the process of developing the new tomato, seeking regulatory approval, and commercialising the product. She showed that the difficulties were not in the genetic engineering itself, but in the business decisions and product development: 'Calgene's lack of expertise in the business it counted on vertically integrating was high on the list of reasons why the Flavr Savr tomato failed' (Martineau, 2001, p. 223). She also mentioned other issues: 'To be fair, the company did experience its share of natural (tropical storms, record heat waves, hurricanes) … disasters in its relatively short lifetime. But to be realistic, those disasters are all … just part of the risky business of agriculture' (Martineau, 2001, p. 223). Ultimately, the company did not produce a tomato that was sufficiently marketable and profitable.

This example shows that the science of gene technology is only one part of commercial success. There are many business challenges that affect transgenic products as much as they affect any food products: cost, logistics, investment, regulation, weather, etc.

3.2.3 AquAdvantage salmon

AquaBounty produced two cohorts of GM salmon at its facility in Prince Edward Island, Canada. In 2023, SeafoodSource reported that the company was discontinuing GM salmon production and instead using the facility to raise non-transgenic salmon eggs (Canadian Biotechnology Action Network, 2023; Chase, 2023). The decision had two elements to it. One, the company decided to focus that facility on egg production rather than producing salmon for harvest. Two, the company did not itself have sufficient capacity to grow out all the transgenic eggs it could produce, so it opted to produced non-transgenic eggs for sale to other companies.

This example shows the importance of flexibility for business so that it can shift to more-profitable products as the opportunity arises. It also shows the connection between control of IP and the investment that can be required to exploit it; in this case, the company did not have sufficient scale to exploit its innovation.

3.3 Additional products

NZIER was limited in the resources it could devote to investigating the history of specific gene technology products and the reasons for their lack of commercial success. Given time and resources, further research could investigate other products and innovations for lessons they can provide regarding the commercialisation process. They include:

- **Canola produced by the company Cibus** – an example of a non-transgenic plant (Heinemann et al., 2021): 'Cibus launched a sulfonylurea tolerant canola in North America in 2016, but it failed to capture much market share and is no longer sold by the company' (Pratt, 2024)
- **Wheat** – Polidoros et al. (2024) indicated that no CRISPR-edited wheat crops have been commercialised. In addition:

  The US Department of Agriculture (USDA) on Aug. 27 announced that it has approved Bioceres' HB4 drought-tolerant trait in wheat, paving the way for cultivation in the United States. However, US Wheat Associates (USW) cautioned that it could still take several years for genetically engineered HB4 to be commercialized in the United States, as there are several more steps taken, including the need to conduct closed-system field trials prior to commercialization (Donley, 2024)
- **Polled (hornless) cattle** – The company that developed two genome-edited calves (Norris et al., 2020)

  initially said that: "We have all the scientific data that proves that there are no off target effects" (quoted in Regalado, 2020), but it overlooked, among other changes, about 4,000 new nucleotides inserted during the application of the new techniques, including antibiotic resistance genes (Heinemann et al., 2021)
- **GABA tomatoes**
- **Non-browning apples**

- **Drought-tolerant maize**.

Analysis of currently commercialised products is also warranted. A small number of crops and traits make up the bulk of GM crops worldwide. 'Interestingly, 70 to 90% of GM crop production globally is used for animal feed' (Flachowsky et al. (2012) and Ritchie and Roser (2021), cited in Caradus (2023a)). These are not high-value, consumer-focused products of the sort that New Zealand should be interested in targeting to improve its economic performance (Conway, 2018; Krieble & Kaye-Blake, 2024; McIntyre et al., 2019; Saunders et al., 2016). The relevance of actually existing commercial success stories to economic conditions in New Zealand needs to be investigated.

3.4 A few lessons from these examples

The examples reviewed here demonstrate that innovations derived from gene technology are still subject to the same commercialisation challenges as any innovation. Working out the science is just the first step. After that, they still need to contend with:

- Time – development and commercialisation take time, during which resources are consumed and the competitive and market landscapes can change
- Investment pressure – scaling up sufficiently to commercialise an innovation can be prohibitively expensive
- Biological pressure – agri-food products are biological products, and as seen in the example of the FLAVR SAVR tomato, weather and adverse events can harm their commercial prospects
- Lack of interest – even where an innovation is successful, there may not be sufficient commercial interest to make it profitable
- Business challenges – commercialisation requires all the usual business functions: management, planning, logistics, marketing, delivery, etc.

The central point is that a science-push focus promoted by the new regulations – *invent it and they will come* – ignores the actual evidence of prior attempts to commercialise agri-food products of gene technology.

4 Economic issues raised by the proposed changes

4.1 Introduction

Law and economics are connected. Law provides a framework for economic claims; economics provides a rationale for legal reasoning (Mercuro & Medema, 1999). Regulations are part of the legal infrastructure of a country. Regulatory changes can therefore be assessed both for their economic reasoning and their economic impacts.

We discuss economic issues related to the proposed regulatory changes under five themes. They are:

- The role of government
- The global market
- Responsibility and risk

- Scale
- Winners and losers.

Under each theme are points or ideas identified through our work and in discussion with OANZ. As we approached each theme, we considered it in light of the impacts on the organics sector, the proposed regulatory changes, the value of New Zealand clean, green image and the value of GE-free for New Zealand.

4.2 Theme 1: Role of government

Governments are important institutions in mixed economies like New Zealand's. At an abstract level, government should be balancing the interests of different actors in the society and economy for the good of the country, however defined. Economics has the notion of a Pareto optimum, named for Vilfredo Pareto. This optimum is an economic outcome in which no one can be made better-off without making someone worse-off. That is, there are no costless gains available. One reason to think in these terms is to avoid comparing one person's welfare with another's. The Pareto optimality criterion compares each person's welfare only with themselves. However, government is inevitably concerned with comparing across people: is the harm caused to this set of people worth the benefit created for that other set?

More concretely, the bureaucracy of government should be providing free and frank advice to the elected Government. That is the statutory role of the public service, and it has a range of tools and processes for fulfilling that role. Tools such as Regulatory Impact Statements (RIS) and Economic Impact Assessments (EIA) have been developed and standardised over time to provide useful and robust information to Government.

In this case, a Regulatory Impact Statement has not been provided. A RIS would (The Treasury, 2021):

- Describe the problem that the change in regulation is intended to address
- Provide more than one option for the change – the purpose is to explain how a different course of action can lead to different impacts and allow decision-makers to understand the trade-offs involved
- Quantify the value of the options – the economic impact of regulations, both costs and benefits, on 'Regulated groups', 'Regulators', and 'Others (e.g., wider govt, consumers, etc.)' are meant to be included in a RIS.

In this case, it would be helpful to further understand:

- Will the proposed regime advance the stated objectives in principle and practice?
- What are the associated costs?
- Do the benefits from the proposed regime justify the costs?

These are topics that a RIS would usually cover. In this report, NZIER is offering its own economic assessments to start to fill the gap. In particular in this case, which will not be a Pareto improvement and will involve harm to some people while benefiting others, it is important to understand the size of the impacts and where they fall.

4.3 Theme 2: Global market

Key New Zealand exports are agri-food and fibre products and tourism services. These exports could be at risk from the proposed regulations, both because of market access and impacts on reputation.

4.3.1 Market access

Market access is New Zealand's legal ability to get products into markets in other countries. Market access can be complex, affected by international agreements and the laws of other countries. In the language of trade negotiations, market access is 'granted': New Zealand does not have the right to sell its goods overseas, but has to obtain permission through negotiation.

An important part of market access is conforming to the rules and standards of the overseas market. Rules around packaging, labelling, product claims, purity, and more are all part of selling products in other countries. If New Zealand's regulations are out of step with those in other counties – particularly if they are less strict – then market access becomes more difficult.

For example, New Zealand allowed the use of the nitrification inhibitor DCD on pasture. The product was considered safe to use for pasture-raised milk production, and DCD was not considered a food safety issue (Ministry for Primary Industries, 2013). After low levels of DCD residues were detected in some milk products, New Zealand dairy products faced a sharp market reaction in China. One exporter of infant formula 'said sales promptly went "to zero" when customers found out about the presence of small amounts in DCD in New Zealand dairy products after the publication of a Wall Street Journal article that questioned the safety of this country's milk' (NZ Herald, 2013) The chemical was well researched, had been used commercially for nearly a decade, and was legal to use in New Zealand (Ministry for Primary Industries, 2013). However, the export market did not consider it acceptable, and New Zealand was forced to withdraw it from use. This is the power of market access considerations.

Another important issue is contamination of export products by unknown GMOs, which was highlighted in Heinemann et al. (2004). Contamination can lead to denial of market access.

4.3.2 Reputation and positioning

Overseas consumers have perceptions of New Zealand and what it represents for them. This is the country's export reputation, positioning, or 'brand', and it has several nuances:

- The official brand is valuable. The '100% Pure' brand is recognised as valuable for New Zealand: it enhances the country's ability to sell exports at good prices (Stewart, 2012).
- There are perceptions beyond the official brand. The 'clean, green image', for example, summarises perceptions about the country without being an official slogan. Nevertheless, it encapsulates New Zealand's positioning in overseas markets (Insch, 2011; PA Consultants, 2001).
- The content of that image is both imprecise and contentious. One version is that New Zealand is a bit of a quiet, sleepy backwater (Carroll, 2022) – simple and unsophisticated. The tourism promise is of an unspoiled environment and authentic experiences (Patil, 2019). New Zealanders also generally understand that image as

Utopian – as not of the here and now (Coyle & Fairweather, 2005). 'However, when this Utopia is threatened by particular biotechnologies such as genetic engineering, New Zealanders' sensitivity to clean and green is heightened in such a way that New Zealand literally "becomes" just that' (Coyle & Fairweather, 2005). The distance between the image and actual environmental conditions causes tension. Some are happy to take the marketing slogan 'with a bit of a pinch of salt' while others use the 'picture-postcard world' to criticise the reality (Stewart, 2012).

It is not clear whether New Zealand exporters are able to make the most of the brand. In work for the Helen Clark Foundation, NZIER interviewed experienced exporters who said that New Zealand companies did not know how to reach overseas consumers and position their products. They felt that New Zealanders were poor at being consumer-centric or market-led, preferring instead to focus on production and pushing products out into the world (Krieble & Kaye-Blake, 2024).

4.3.3 Opportunities

One aim of economic analysis is to understand the potential for growth and change in the country's interactions with global markets. The proposed regulatory changes have pointed to the opportunity for economic growth through gene technology (Ministry of Business, Innovation & Employment, 2024). Other opportunities exist as well:

- Organics as progress – research shows that consumers are interested in making ethical consumption choices. They want their purchases to be linked to environmental sustainability, animal welfare, and other good causes. They want their choices to support progress on challenges facing society. It is possible to position organics in exactly this way: a production method that is good for consumer and good for the planet. However, the proposed regulations represent a threat to that opportunity.
- Māori products and branding – Māori people and organisations control significant assets in the agri-food and fibre space, and Māori culture is a unique tourism offering for New Zealand. The potential to sell products and services to the world based on Māori branding or Māori kaupapa has been recognised and explored. However, maintaining the option of developing this opportunity requires understanding how gene technology is perceived from a Māori perspective.

There is more than one way to create and support economic opportunities in global markets. The fact that gene biotechnology may be one approach does not mean that other approaches are not available. Good policy would maintain a large 'option space' for New Zealand's future: keeping many possibilities alive for as long as possible while their relative economic merits are investigated, debated and explored.

4.4 Theme 3: Responsibility and risk

A key concept in economics is that risk should be connected to reward. The person who takes a risk should also receive the benefit if successful and bear the costs if not. This arrangement enables the correct amount of risk to be taken at an aggregate level. If people do not bear enough costs for risks, then they take too much risk and harm the collective wellbeing. If they are not rewarded for successful risk-taking, then collectively there isn't enough experimentation and innovation in the economy. However, because innovation has both private and social benefits, mechanisms for insulating risk-takers from costs – such as the limited liability corporation – and forgiving losses – such as bankruptcy – can be socially

beneficial. The question is finding the right amount of responsibility and reward that promotes an optimal level of risk-taking at the aggregate level.

The proposed regulations have some elements that suggest they would support a sub-optimal level of risk-taking.

- Focused benefits, diffuse costs – gene technology allows the innovator to control access to the innovation. Intellectual property rights – patents and other tools – allow innovators to commercialise innovations, which means they can charge people for using them. However, the potential costs discussed in this report – loss of reputation – could be felt widely across the agri-food and fibre and tourism sectors. Those wider costs do not feature on the private cost-benefit assessment of the individual innovator.
- Ex-post liability – calculations of expected value or risk-adjust reward that are made beforehand – ex ante – rely on assumptions about the future. However, it is difficult to get predictions correct, and entrepreneurs tend to have a bias towards optimism. The proposed regulations would leave it to the courts to sort out liability afterward – ex post. This mechanism would likely be too weak: optimism bias would lead entrepreneurs to take too much risk; the time required to achieve a settlement would disadvantage some people; and the tail risk (high-impact, low-probability outcomes) would not be sufficiently compensated because of the liability-limiting mechanisms discussed above.
- Bad actors – the proposed regulation involve reducing oversight on gene technology and becoming an international outlier. Those changes would encourage people and companies to come to New Zealand to experiment. They would also encourage bad actors to try their luck in a weakly regulated environment. One possibility is a race to the bottom: poorly capitalised companies with weak ties to New Zealand experimenting without oversight in the hopes of finding success, but able to exit quickly if the experiments go badly.

The proposed regulations would likely encourage New Zealand to take on more risk from gene technology than is economically optimal. The individual innovators making decisions about growing specific crops would benefit from the upside risk but not bear sufficient costs from the downside risk. Their individual calculations would lead the country to take on more risk in aggregate than is optimal.

4.5 Theme 4: Scale

A key feature of modern industrialised economies is scale. Large, standardised production, distribution, and retailing activities create efficiencies and reduce costs, ultimately leading to reduced prices and increased consumer welfare.

The New Zealand economy struggles with scale, a fact mentioned by several economic researchers and commentators (Conway, 2018; Krieble & Kaye-Blake, 2024). There is only one city that could be considered internationally significant (McCann, 2009), the cities in New Zealand tend to have poor agglomeration effects (Lewis & Stillman, 2005), and most industries and businesses are small by international standards. While Fonterra represents about 30 percent of global dairy exports (Office of the Minister of Energy and Resources, 2023; Scott et al., 2013), New Zealand produces only about 3 percent of the world's dairy products (Lynch, 2021). The reason for the difference is that most dairy production is consumed domestically – countries feed themselves.

New Zealand also struggles with low capital investment (Conway, 2018; Krieble & Kaye-Blake, 2024). Building scale requires investment in plant and equipment, technology and skills. New Zealand on an economy-wide basis simply does not tend to invest sufficiently to create scale.

It is unlikely that New Zealand would create enough scale with any organism created through gene technology, not like the size of the soybean and maize crops in other countries. As a result, the more likely approach to commercialisation is to develop something in New Zealand and then sell or licence the intellectual property (IP) for use overseas. That approach could provide enough scale. However, commercialisation of IP is a different economic proposition than creating products to benefit New Zealand farmers. The only species that might create enough scale in New Zealand productive systems would be pasture species: ryegrass, clover and the like. Creating regulations for these few species for the benefit of New Zealand does not seem to warrant a wholesale change in the regulatory regime around gene technology. Simply put, the proposed approach does not match the economic reality.

4.6 Theme 5: Winners and losers

Where government intervention has an impact, it is where the intervention changes what would 'naturally' happen. If the economy is already producing the desired results, there is no reason to intervene.

Government intervention produces winners and losers. Someone does better than they otherwise would, and as a result someone else does worse. This does not have to be strictly zero-sum: gains could be greater than losses. It could also be beneficial: the gains can be the sort that people want to see, and they are willing to put up with the losses or the costs.

This is the source of the criticism that a government policy is 'picking winners'. It is not so much the picking of winners that creates the problem, it is the costs imposed on everyone else. It is also the opportunity costs, the idea that those resources could have been used better without government intervention.

For the proposed regulations, costs are being imposed on the organics sector. The government not so much picking winner as picking losers: it has decided to create additional costs for the actual, existing organics sector in exchange for the promise of future gains from gene technology.

One question is, why now? As Small (2015) made clear, there is no current gene technology that needs this regulatory change in order to advance commercially. Given the timescales involved in technology development, there would be sufficient time to revise regulations in the future when an economically beneficial innovation appears.

A second question is, why is there no economics in the regulatory information (Ministry of Business, Innovation & Employment, 2024)? Economic analysis can provide useful information about the size of potential economic gains and losses. That information can be used to determine the best course of action for government policy, weighing up economic impacts and other criteria.

The New Zealand organics sector is nearly $1 billion in total sales including exports, according to OANZ. The organics sector also represents opportunities for growth. Consumers are a diverse group who respond to different value propositions. Some are environmentally minded and respond to messages about clean, green production methods.

Some are more focused on personal health and the potential impacts of agrichemicals; they respond to messages about purity and naturalness. There are opportunities to establish what motivates these consumers and provide them with products that support their values, and thereby capture more of the consumer dollar and return it to New Zealand.

Government policies tend to produce winners and losers. In this case, it is not clear either what we are giving up in terms of an existing sector with obvious opportunities, or what we are gaining in terms of specific, measurable, achievable, relevant and time-bound benefits to the New Zealand economy.

5 Conclusion

OANZ engaged NZIER to consider the economics of proposed regulatory changes around gene technology. The media pack provided by MBIE suggested that no economic analysis was available and none would be attempted. NZIER has therefore used its economic expertise to provide perspective on:

- The value of New Zealand's brand and different market messages for export markets, as a way of estimating the potential economic cost of the proposed regulatory changes
- Lessons from the actual experience of gene technology worldwide, in which a small number of crops are used for low-value purposes and many products – even ones that are fully scientifically developed and not subject to additional regulation – fail to be successfully commercialised
- The issues raised by the proposed changes, including connections between law and economics, the treatment of risk and reward, and the relevance to New Zealand's economy.

NZIER agrees with Caradus (2023a) that a discussion of gene technology in New Zealand should include all the economic actors affected and quantitative analysis to understand the impacts.

The quantitative analysis we have been able to conduct with limited time and resources suggests that environmental release of GMOs in New Zealand could reduce exports from the primary sector by up to $10 billion to $20 billion annually. However, few studies have investigated this exact question and they lead to a range of conclusions, including a conclusion of no impact at all. The uncertainty around these estimates is a reason to investigate the potential economic consequences further before regulatory changes are adopted.

NZIER understands that gene technology has potential benefits, as outlined by MBIE (2024). As professional economists, we also understand that there is no free lunch. Any assessment of the potential of gene technology should also account for possible costs. We hope that this report provides a first step in understanding those costs.

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Appendix A Key points from the literature

Table 5 Selected sources consulted and key points from them

Source	Key points
Agribusiness and Economics Research Unit (n.d.)	This website reports the results of the AERU's multi-year, MBIE-funded programme Maximising Export Returns. It includes a data tool for exploring consumer premiums, including for organics and GE-free, for New Zealand products in export markets.
Baker (2017)	'New Zealand's standing on a global stage is in "excellent shape", according to the author of an international reputation index.'

Source	Key points
Bautista (2024)	The Philippines Court of Appeals stopped the propagation of Golden rice in the country 'over the lack of "full scientific certainty"' on its impact.
Bendetti et al. (2022)	This webpage from Boston Consulting Group highlights the importance of uncertainty for managers and organisations. The green economy, including organic food and beverages and eco-tourism, is a opportunity for New Zealand. While it mentions bioengineering, it limits that discussion to alternative proteins.
BioGro (n.d.)	GE-free and organics are a point of difference that supports the 100% Pure New Zealand brand, worth $440 billion in 2022.
Bradley (2024)	This news article reports on the 25th anniversary of launching the 100% Pure brand. 'The campaign has been attacked because of New Zealand's less than pure environment, which an outspoken critic says is still the case. But as a way of promoting the country has been described by tourism academics as world-leading.'
Caradus (2023a)	'Interestingly, 70 to 90% of GM crop production globally is used for animal feed', raising questions about the value of New Zealand remaining GE-free. Investigating the issue would involve 'quantifying the comparative value of organic produce and the GM free status of the country across different market segments'.
Caradus (2023b)	'While there will always be a proportion of consumers against the use of GM in food production, the published evidence would suggest that the use of GM plants in New Zealand for food production will have no long-term deleterious effects in overseas markets. From a regulatory view point, the focus should be on regulating the benefit-risk issues associated with the end-product of genetic modification rather than the processes used in their development.'
Carroll (2022)	'New Zealand' as a brand is worth $440 billion. It allows New Zealand to achieve premium prices for goods and tourism. It is associated with 'integrity, ingenuity, care, and respect.'
Controller and Auditor-General (2017)	Countries have brands, and New Zealand has a strong global reputation for safe and high-quality food
Coyle & Fairweather (2005)	New Zealand's clean green image is a 'place myth', and the government is offering biotechnology innovation as an alternative place myth. For some people, the clean green myth anchors a reluctance to take up biotechnology. For others, biotechnology could be a tool for creating a clean green New Zealand.
Coyle et al. (2003)	This report presented findings from focus groups in New Zealand about biotechnology. Perceptions of biotechnology were linked to underlying attitudes and values. 'New Zealand's clean green image was seen as a national icon, but one that existed either in the past or was a future utopia that participants strived to reach.'
Department of Conservation (2006)	Conservation land provides a platform for businesses to operate sustainably. This report estimated the economic impact of conservation land for several locations. Across the locations, the total impact was hundreds of millions of dollars of contribution to gross domestic product and thousands of jobs.
Driver et al. (2023)	This detailed review of studies reported that prior work found consumers willing to pay 9 percent to 22 percent more for meat produced without GM feed. Premiums for GMO-free were zero to 89 percent.
Guenther et al. (2017)	The organics sector was estimated to be $457 million to $467 million in output. Key markets were the US and Europe. International harmonisation of organics standards underpins New Zealand's exports.

Source	Key points
Heally et al. (2023)	This webpage from Boston Consulting Group highlights the opportunity for New Zealand to be part of the global green economy, expected to reach $9.4 trillion by 2030. 'Sustainable farming is important, as 89% of New Zealand's exporters believe that New Zealand's Pure brand image is important to their business, including in the agricultural sector.'
Heinemann et al. (2004)	International trade in agricultural products includes regulations about gene technology. They are vulnerable to error, which can disrupt trade.
Hoggard (2024)	China and New Zealand signed an upgraded Mutual Recognition Agreement for organic products that is expected to boost New Zealand exports of organic products.
Insch (2011)	The clean and green positioning can be linked to New Zealand national identify since the 1970s. 'New Zealand gained attention for its stance against nuclear energy and genetically modified organisms in the 1980s.' 'The Ministry for the Environment (2001) estimated that the country would lose about NZ$938 million in revenue from its five inbound tourist markets (Australia, Korea, the US and UK, and Japan) if tourists' perceptions of the environment worsened.' New Zealand's tourism brand was worth US$13.6 billion, according to Interbrand (2005).
International Rice Research Institute (n.d.)	This webpage answers Frequently Asked Questions about Golden rice. 'When Golden Rice made headlines in 1999, it was in its "proof of concept" phase. The process of researching and developing Golden Rice is rigorous, complex, and meticulous, and under no circumstances must it be rushed. For instance, climate-smart, flood-tolerant rice, which millions of farmers can now access, took more than two decades to develop.'
Kaefer (2016a)	This blog post based on a doctoral thesis reviews the origins of the clean green image and how it connects with national identity. New Zealands do connect with the clean green image but also do not fully believe it.
Kaefer (2016b)	This blog post based on a doctoral thesis notes that the 100% Pure brand connects with imagery about New Zealand going back to colonial times. The brand resonates with New Zealanders.
Knight et al. (2013)	Based on face-to-face surveys with 515 overseas tourists at Auckland airport, the authors 'conclude that it is highly unlikely that introduction of GM plants into new Zealand would have any long-term deleterious effect on perceptions in overseas markets of food products sourced from new Zealand. Furthermore it is highly unlikely that New Zealand's image as a tourist destination would suffer if GM plants were introduced.'
Knight (2011)	This report summarises interviews, choice modelling studies and a visitor survey (also in Knight et al. (2013)) and concludes 'that it is highly unlikely that introduction of GM drought-tolerant pasture into New Zealand would have any long-term deleterious effect on perceptions in overseas markets, particularly in Europe, of food products sourced from New Zealand.'
Massel (2023)	Distinguishes between genetically modified organisms (GMOs) and gene-edited foods. Discusses several examples of crops made with different gene technologies. 'The fact is, we don't really understand the genomes of many plants and animals we eat. So there's no reason to suggest tweaking their gene sequences will make consumption harmful.'
McIntyre et al. (2019)	This report from the Our Land and Water National Science Challenge presents case studies focused on understanding how to generate greater returns to New Zealand through value chains, highlighting the importance of shared 'values' in creating economic 'value'.
Merfield et al. (2015)	This journal article uses data from the ARGOS project in New Zealand to explore the relationship between organic farming standards and agricultural sustainability. 'We conclude that adherence to organic standards

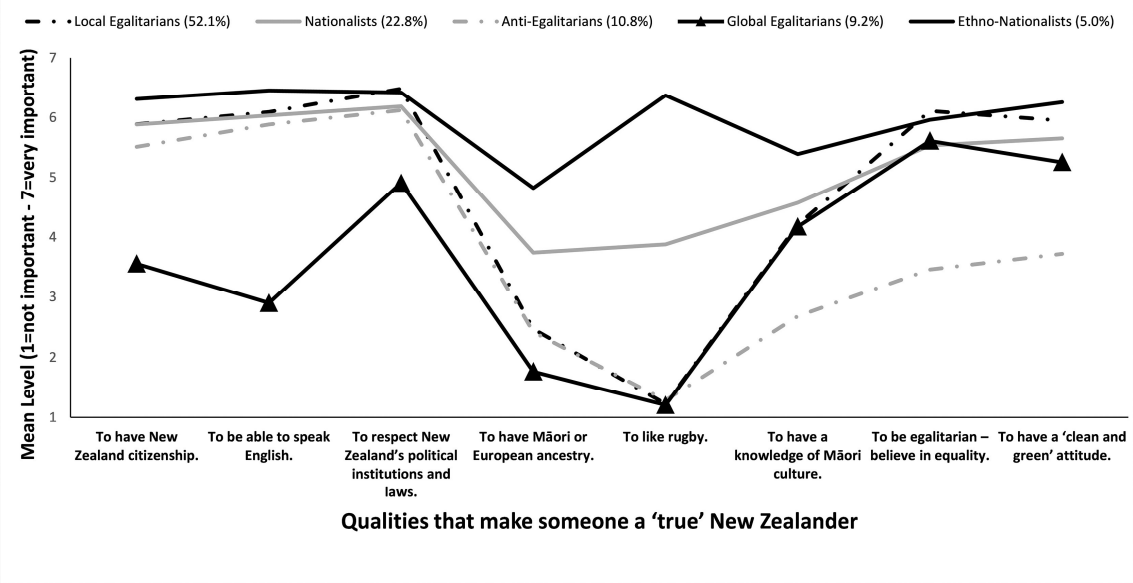
Source	Key points
	undoubtedly promises some gains in ecosystem services, including the crucial cultural ones that assist systems adaptability and learning – but we also assert that organic standards will need to be combined with more targeted farming systems interventions across multiple criteria to maximise sustainability of organic farming.'
Milfont et al. (2020)	The research 'identified five profiles about being a 'true' New Zealander.' 'Over 89% of participants placed high importance on having a clean-and-green attitude.'
Ministry for Primary Industries (2013)	This announcement from MPI explains the withdrawal of DCD, a nitrification inhibitor, from use in New Zealand. 'The withdrawal of the DCD product ensures that there is no source of DCD that could enter the milk supply in New Zealand or its exports of milk products.'
Ministry for Primary Industries (2023)	'The global consumer market for natural & organic products is estimated to be worth USD $360B by 2031.' 'Natural' products and 'tech-based' products may not be mutually exclusive, which 'may require future thought'. Promotes having a discussion about the use of gene technology in future value propositions.
Ministry of Business, Innovation & Employment (2024)	The media pack on changing the gene technology regulatory regime has been discussed elsewhere. The summary graphic is presented in Figure 1.
Morton (2024)	This news article reported on the proposed new gene technology regulatory regime. The potential impact on exports is not known.
Nepia (2013)	This Master's dissertation assessed '100% Pure' using semiotics (the study of signs and symbols). It noted that prior research found tourists split on whether the 100% Pure message was accurate; some tourists felt misled. It reviewed some of the disputes around the brand. Despite the disputes, the brand has been successful.
New Zealand Trade and Enterprise (2023)	This webpage summarises research by Kantar showing that New Zealand has a strong premium country brand, especially in China and Australia. 'Ultimately, premium F&B consumers across our core markets want great tasting, premium quality products from a place they can trust.'
NZ Herald (2013)	The issue of traces of DCD being found in samples of dairy products had seriously hurt exporters.
Organics Aotearoa New Zealand (2021)	This report provided data on the economic contribution of the organics sector, as well as information about consumers, export markets and trends. 'The organic sector generates approximately $620 million in export and domestic market revenue'.
PA Consultants (2001)	This milestone report for the Ministry for the Environment put a value on New Zealand's clean and green image. Losing the clean and green image could cost the dairy sector $241 million to $569 million, and cost tourism $530 million to $938 million (all in 2005 dollars). Impacts on the organics sector from a release of GM crops were expected to be large: 'Adopting a policy of uncontrolled release would see New Zealand almost certainly suffer immediate losses, with buyers either stopping or substantially decreasing purchases.'
Padhye et al. (2022)	New Zealand has an image of being clean and green, but needs to tackle pollution problems to back up that image.
Patil (2019)	The 100% Pure brand has successfully boosted tourism to New Zealand, but it has also triggered a critique of environmental conditions in the country.
Patron & Price (2021)	This article presented basic information about GM crops, gene editing and food.

Source	Key points
Polidoros et al. (2024)	'CRISPR-edited crops present a promising frontier for sustainable agriculture, global food security, and climate resilience, highlighting their potential to significantly benefit both producers and consumers alike'. This article identified eight genome-edited commercialised products/crops, and 11 products/crops (some going back to 2016) that are approved but not yet commercialised.
Regis (2019)	This article was an excerpt from the book *Golden Rice: The Imperiled Birth of a GMO Superfood*. It summarised the history of the development of the crops and the challenges it has faced, regulatory and otherwise.
Saunders & Emanuelsson (2005)	Organics had a small market share but high growth in the 1990s and early 2000s. Price premiums varied a lot, and offset the lower levels of output from organic farms. Increasing production of organic commodities might be beneficial under certain production and market conditions.
Saunders et al. (2013)	The price premium for food products from New Zealand varied by country (China, India and UK) and product (dairy or lamb). The range was 3 percent to 49 percent.
Small (2015)	This document was a legal filing concerning GMOs and Auckland policy. It provided an economic assessment from senior New Zealand economist. Important concepts were uncertainty, lack of commercially relevant products, the market benefit of GM-free, and the reversibility of blocking the outdoor release of GMOs once economically products become available.
Smol et al. (2019)	This report examined 100% Pure New Zealand and 'Brand New Zealand'. It found they were successful and used by several sectors, not just tourism. It does not provide an estimate of the economic value of the brands.
Stewart (2012)	This news article discussed the gap between the 100% Pure brand and criticisms of New Zealand's environmental performance.
Tait et al. (2018a)	Overseas consumers were willing to pay a premium for several credence attributes.
Tait et al. (2018b)	Overseas consumers were willing to pay a premium for several credence attributes.
Tait et al. (2018c)	Overseas consumers were willing to pay a premium for several credence attributes.
Tait et al. (2018d)	Overseas consumers were willing to pay a premium for several credence attributes.
Tait et al. (2013)	Chinese and Indian consumers were willing to pay a price premium for New Zealand dairy and lamb, reflecting perceptions of safety, animal welfare and environmental performance.
TPBO (2016)	Clean and green is an umbrella brand and integral to New Zealand's marketing in tourism and food. There are several valuations of different brand perceptions.
Waltz (2016)	The US Department of Agriculture determined that it would not regulate the non-browning, CRISPR-edited mushroom developed at Pennsylvania State University.
White (2016)	European expert/trade buyers have a positive view of New Zealand as a country of origin. The clean green positioning is part of New Zealand's overseas reputation.
Wikipedia (2024)	'As of 2020, no genetically-modified wheat is grown commercially, although many field tests have been conducted. One wheat variety, Bioceres HB4 Wheat, is obtaining regulatory approval from the government of Argentina.'

Source	Key points
Yang et al. (2020)	This meta-analysis found a price premium for environmentally friendly dairy products that ranged from 5.3 percent to 47.5 percent.
Yang et al. (2023)	In comparing food claims by companies from Australia and New Zealand, this journal article found that 'green' and 'ethical' claims were associated with launches in New Zealand but not Australia. This finding provides evidence of firms tailoring their messages for different consumer groups.

On the topic of perceptions of New Zealanders regarding the clean and green image, Milfont et al. (2020) identified different groups of New Zealanders and their attitudes toward that quality or idea.

Figure 2 Diversity of New Zealand identities



Source: Milfont et al. (2020)