Report to
Ministry for the Environment and the Treasury
on

Economic Risks and Opportunities from the Release of Genetically Modified Organisms in New Zealand

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Manatū Mō Te Taiao

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Disclaimer

This report was prepared by a project team led by Business and Economic Research Limited (BERL) and should not be taken as representative of the views of the Ministry for the Environment or the Treasury.

Peer review

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This report should not be taken as representative of their views.

Economic Risks and Opportunities from the Release of Genetically Modified Organisms in New Zealand

The Ministry for the Environment and the Treasury commissioned Business and Economic Research Limited (BERL) to lead a team to carry out this investigation of the economic impacts of releasing genetically modified organisms (GMOs) in New Zealand. This research forms part of the government's response to the Royal Commission on Genetic Modification. The government sought an economic analysis of the risks and opportunities that may arise from the use of genetic modification and non-genetic modification technologies. This research will assist in making decisions on the overall strategy of preserving opportunities and proceeding with caution with genetic modification. Other government decisions can be found at the Ministry for the Environment website – http://www.mfe.govt.nz/issues/organisms/legislation/.

New Zealand has not approved the release of any GMO either in primary production or in any other industry. Therefore, there is no information available about the impacts on the New Zealand economy of a release of a GMO. In order to gather information, BERL was commissioned to lead a team to assess what the economic impacts might be. BERL and its team have tackled this issue by undertaking a survey of international consumers, gatekeepers and inbound tourists, and by employing two economic models. The survey was used to give an indication of the impact of a GMO release on New Zealand's clean green image, and the extent of any price impacts on the use or avoidance of GMOs. The modelling was carried out using a partial-equilibrium trade model to estimate the specific effects for producers, and a general-equilibrium model to estimate the effect these producer returns would be likely to have on the wider economy.

It is important to emphasise that the research is based on the modelling of four hypothetical scenarios and a snapshot consumer survey. The findings rest on a set of assumptions and a specific methodology that is a simplification of reality. While informative, the findings are indicative and give a mix of economic impacts.

The research was funded through the Cross Departmental Research Pool of the Ministry of Research, Science and Technology. The Treasury also provided funding for additional analysis. The work has implications across government, and consequently was overseen by a steering group comprising representatives from the Ministry for the Environment, the Treasury, the Environmental Risk Management Authority, Ministry of Agriculture and Forestry, Ministry of Foreign Affairs and Trade, and the Ministry of Research, Science and Technology.

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The base case: New Zealand's clean green image

Surveys of respondents in overseas markets and inbound tourists within New Zealand confirmed that in the perception of environmental image, New Zealand was consistently ranked 'above average' or 'among the best'.

The survey in overseas markets was of a net sample of 444 people in three of New Zealand's main overseas markets, namely Australia, United Kingdom and United States. The respondents' image of the New Zealand environment was excellent, with 85% in both Australia and United Kingdom stating that their image of New Zealand's environment was 'above average' or 'among the best', and only 5% had no image of New Zealand. The remaining 10% had images of New Zealand as average or below. The response was different in United States where only 70% had images of New Zealand as 'above average' or 'among the best', and this difference was perhaps because 19% had no image of New Zealand. Similar to the other two markets, in United States 10% had images of New Zealand as average or below.

The survey of inbound tourists was of a sample of 93 visitors to Christchurch, 99% of whom had an image of New Zealand ranked 'above average' or 'among the best'. Clearly none of these respondents had no image of the New Zealand environment, and only 1% thought it was 'average'. Variations in percentages between these two surveys can be expected because of the relatively small sample sizes, and, with the inbound tourist survey, the reality may have reinforced their prior perceptions. There could also be some "be kind to host" effect which could have biased their responses.

In terms of New Zealand phrasing, these surveys confirmed that New Zealand has a clean green image (CGI), with its existing genetic modification (GM) status. Questions remain as to the value of the CGI in overseas markets.

Impact on CGI of changing New Zealand's GM status

The release of genetically modified organisms (GMOs) would have a varied impact on that image. If New Zealand was to use GMOs in pest control or livestock feed, approximately 55% of respondents stated their image either would not change or would improve in such a situation. This included 29% who stated their image did not change and 25% who said their image would improve. Approximately one-third of all respondents stated that their image of the New Zealand environment would get worse.

If New Zealand was to use GMOs in human disease prevention, approximately 68% of respondents stated their image either would not change or would improve. This included 29% who stated their image did not change and 39% who said their image would improve. About 20% said their image of the New Zealand environment would get worse.

These numbers show that the magnitude of the effect on New Zealand's CGI of GMO release would depend upon the purpose for which the GMO is released. There are also variations in response in different markets.

If New Zealand were not to use GMOs, then over 50% stated that their view of New Zealand's image would remain unchanged, while one-third of overseas respondents stated their image would improve. Of inbound tourists, nearly 50% stated that their image would stay the same, and a similar percentage stated their image would improve.

World consumer reaction to release of GMOs

Survey results indicate that the release of GMOs in New Zealand would have an impact on foreign consumers' purchase intentions. A large group of consumers (between 40% to 70%) state their purchasing behaviour would remain unchanged. This share ranges from 43% who whose fruit purchasing intentions would remain unchanged, through 54% with dairy product purchasing, to 72% whose holiday choice would remain unchanged if there was a release of GMOs in New Zealand.

A significant group of consumers (ranging between 20% to 30%) also state they would cease purchasing New Zealand commodities if New Zealand released GMOs, though only a much smaller 5% to 10% would not choose New Zealand for a holiday in that instance. From the smaller survey of inbound tourists, the numbers were substantially lower than these.

In addition to these two groups, there is a third group of consumers. This group indicates that their responses would be contingent on prices, and the degree of sensitivity to price changes is considerable. This implies that there are consumers who, following a New Zealand GMO release, would be disinclined to buy but would re-enter the market if there were a relatively small reduction in price. The characteristics of these groups of price-responsive consumers has enabled us to determine the impacts on demand for New Zealand goods and services following a GMO release, and flexibility of pricing and supply by New Zealand suppliers in the export markets.

The stated purchasing intentions if New Zealand's GM status changed, as measured by these two surveys, provided the information on expected world market demand changes in the various scenarios of the economic model experiments.

There is uncertainty around the relationship between the purchase intentions as stated in the surveys and the actual point-of-sale purchases. At least two factors need to be borne in mind when generalising from scenarios as presented in a survey to 'real life'. The first relates to information at point-of-sale. It is unlikely that consumers would know, or bring-to-mind at point-of-sale, the GM attributes of New Zealand in other contexts, and yet in the survey context this has, of necessity, been brought specifically to their attention.

Secondly, the price-quality characteristics of the product, relative to those from other countries can assume a powerful if not predominant influence in the product choice for many consumers, including, in particular, trade-offs of immediate tangibles (cost, appeal) against intangible and more remote perceptions of other considerations like GMOs.

One type of consumer response is not sensitive to price but expresses an aversion to GM food that is categorical, a similar purchasing behaviour to vegetarians or consumers guided by religious codes.

The durability of the consumer perception figures will depend on the dissemination of favourable, unfavourable and neutral information about GMOs, and the way the public receives this. It is common for people to be cautious about such innovations until sufficient time has elapsed for them to be proven.

In other words, it has to be acknowledged many influences determine purchase behaviour. Price is one of these influences. Amongst others is a wide spectrum of product characteristics integrated with buyer knowledge and taste preferences. In addition, these influences change across time as external events impact on consumer behaviour.

The relationship between stated consumer perceptions and actual purchasing patterns is also likely to be compounded by the behaviour of institutional 'gatekeepers' in a range of export markets. In some cases their behaviour may amplify consumer concerns. If consumer attitudes on GM remain stable over time, 'gatekeeper' behaviour is likely to reflect those attitudes. Should consumer attitudes in markets change, the 'gatekeeper' behaviour could be expected also to change.

Technology and New Zealand production system

New Zealand's main productive industries are based on production from plants and animals and so economic wealth could be created by GMOs applied in agriculture, horticulture, plantation forestry, aquaculture and medicine. GM also has the potential to create entirely new products and sectors of economic activity.

Three specific examples of GMO releases were investigated and scenarios specified for pastoral agriculture, pest control, and human therapeutics. These scenarios assume effects on productivity in industries due to the release of GMOs.

Economic model experiments

Two economic models were used to undertake various experiments simulating the impact on the New Zealand economy of the release of GMOs, as well as the scenario of New Zealand foregoing GMOs: an agricultural trade model and an economy-wide model.

The modelling assumes similar consumer reactions across all markets, derived from the 'average' reaction calculated from the survey responses. Consumer preferences and concerns are, however, likely to vary over markets. Furthermore, the modelling assumes that consumers are able to choose between a range of suppliers – distinguished by their GM status – of the products (and holidays) they wish to purchase. The model experiments should therefore be interpreted within the context of the diversity of the markets in which New Zealand exporters are active.

The agricultural trade model is ideally suited to investigating the impacts on the New Zealand agriculture sector in response to changes in productivity, commodity demand and supply, and the consequential changes in world prices and producer returns.

The economy-wide model is better suited to investigating the impacts on the wider New Zealand economy. It captures the influences of relationships between sectors as well as the impacts when resources shift from one sector to another.

Scenario impact on New Zealand economy 10 years hence

The numerous experiments performed using the two economic models signal a range of outcomes in terms of economic impact.

The agricultural trade model indicates that change in GM status has significantly large effects on New Zealand agriculture industry. In particular, the results find the world market reactions (export demand responses) significantly larger than the impact originating from the supply reaction (ie. productivity increases or cost reductions).

New Zealand releases GMOs

From the agricultural model, the release of a GMO that results in 2.5% pa higher productivity for 10 years with *no* demand response leads to only a 5.1% increase in New Zealand agriculture producer returns. However, a demand change reflecting a 20% discount on *all* New Zealand exports of dairy, meat and fruit with *no* productivity changes, leads to a 43% reduction in producer returns.

From the economy-wide model, the impacts of productivity changes are relatively greater, as increased productivity in one industry makes more resources available to other industries. This effect is captured by this model. The effect of a more price-sensitive foreign consumer is also included in this model so that the impact on export returns is more muted.

As a result of the assumed negative demand reaction to the release of a GMO in New Zealand (as indicated by the consumer intentions from the surveys), and assuming that the GMO release provides *no* productivity increase, the economy-wide model finds that GDP 10 years hence is 2.4% lower than it otherwise would have been. In this experiment dairy and meat export returns are 8.2% lower than the base case.

On the other hand, a GMO release which generates an assumed 2.5%pa higher productivity in pastoral agriculture, and assuming this release causes *no* demand reaction, results in GDP being 2.5% higher 10 years hence. In this case, dairy and meat export returns were 8.9% higher.

Clearly in any particular case one could expect a GMO release to cause *both* some reduction in demand for some products in some markets, and some increase in productivity. The effects on GDP in 10 years time would therefore be expected to be between these two limits of GDP 2.4% lower and 2.5% higher than would otherwise be the case, and the various scenarios modelled gave such results.

In particular, the experiment *combining both* the productivity and demand responses resulted in GDP 10 years hence being lower by 0.1%. The sensitivity of this outcome to the magnitude of the demand response was also tested. The experiment with a 50% large export demand reaction resulted in GDP being lower by -1.3%, but if the export demand reaction was 50% smaller the outcome for GDP 10 years hence was 1.2% higher.

New Zealand refrains from GMO release

Where New Zealand refrains from releasing GMOs, the trade model finds that other countries' increasing productivity with GMOs has little impact on producer returns. In contrast, a demand effect resulting in a 20% preference for non-GM products increases New Zealand producer returns by 33% above the base case.

The economy-wide impact of a New Zealand refraining from release of GMOs was also modelled. This experiment showed a shift in preference to New Zealand-labelled dairy and meat, as well as a shift to all New Zealand fruit and holidays, which together led to 7.5% higher GDP 10 years hence. In this case, dairy and meat export returns were 14.5% higher. However, if other competitor countries adopted GMOs which led to their enjoying greater productivity improvements, New Zealand GDP would then be 6.4% lower than in the base case. Dairy and meat export returns were over 40% lower.

Conclusions on economic outcomes

The general conclusions on the economic outcomes are that while the impact of single influences (either world market demand effects or New Zealand production opportunities) are potentially large, together many of the influences counter each other.

Because of the counter-balancing influences, the actual effect on New Zealand's annual GDP 10 years hence is thus not very great under any of the scenarios. Impacts at the level of the individual industry – especially the agriculture industry – remain significantly large. In particular, demand shifts tend to have relatively larger impacts on agricultural returns that do supply shifts.

The results of the Lincoln agricultural trade model suggest that a supply-side strategy focusing on raising New Zealand's productivity would be less effective at increasing producer returns than would be a demand-side strategy raising demand for New Zealand products. However this model does not take account of the resources released to the other industries in the economy when resource productivity in agriculture is increased. These effects are specifically embodied in the economy-wide model.

Numerous experiments using the economy-wide model, combining aspects of both influences found economic outcomes, in terms of the level of GDP in 10 years hence, ranged from 3% higher GDP to 3% lower GDP.

In other words, the impact of releasing a GMO in New Zealand or not using GMOs in production could result in both negative and positive overall economic outcomes.

Critical factors determining economic outcome of GM status

Assessments of the detailed results of the economic experiments has enabled us to isolate four critical elements that determine the economic outcome.

(1) The magnitude of the change in demand for New Zealand goods and services

This factor describes the extent to which the purchase decisions of foreign consumers for New Zealand goods and services is dominated by their desire to buy from a country where there are no GMOs released. If the survey responses are reflected by actual purchase behaviour, such behaviour has significant and substantial negative consequences for New Zealand's conventional export commodities and, consequently, the wider New Zealand economy. There is uncertainty attached to actual behaviour, justifying the close monitoring of consumer attitudes and purchasing. International research indicates that when faced with actual purchase decisions at point-of-sale, consumers' reactions will be different from what they say they would do in "willingness to pay" surveys.

The price-quality characteristics of the product displayed, relative to those from other countries can assume a powerful if not predominant influence in the product choice for many consumers. It is also unlikely that consumers would know, or bring-to-mind at point-of-sale, the GM attributes of New Zealand in other contexts, and yet in the survey context, of necessity this has been brought specifically to their attention.

The origin country of products is not necessarily identified on supermarket shelves. It is likely that the labelling of products as GM or non-GM could influence consumer behaviour rather than the country of origin.

(2) The response of foreign consumer demand to price changes

This factor describes the extent to which the purchase decisions of foreign consumers for New Zealand goods are influenced by price differentials between commodities from other countries. This price responsiveness can allow New Zealand to counteract loss of sales to CGI-sensitive market segments by reducing prices and thus increasing sales in other market segments.

(3) The access of New Zealand goods to global markets

Associated with the consumer reactions to the release of GMOs in New Zealand, described by the first two factors, is the institutional, regulatory, commercial aspect of access for New Zealand products to particular world markets. In many markets the actions of regulators and gatekeepers (for example, retailers, wholesalers, traders, buyers for supermarket chains and others) can mirror, amplify or in some way modify the effective consumer demand.

(4) The opportunities for productivity enhancements

This factor describes the extent to which GMO releases can improve productivity or open new opportunities in New Zealand industry. If these productivity improvements, leading to cost reductions, occur at historically comparable rates, significant gains to the New Zealand economy can be recorded. In this case though, the achievability of such gains are contingent on New Zealand overcoming quota, regulation and other market-access barriers to expanding New Zealand commodity sales in key markets. On this production side there are potential benefits from a portfolio of GMOs with a range of effects on productivity, product quality and the environment.

The degree of uncertainty surrounding all four elements is considerable. As such, it remains important for New Zealand to manage GMO-related activities for the benefit of all New Zealanders. Progressively reducing the degree of this uncertainty over time will be a prerequisite to reaching a conclusive statement on the economic outcome of either a GMO release or a policy foregoing GMO release.

The results of the economic experiments confirm that establishing actual (as opposed to surveyed) purchase response to GMO release is pivotal to determining its impact on the New Zealand economy. Similarly, more information aimed at confirming the actual (as opposed to asserted) productivity gains from GMO release another critical pre-requisite for a conclusive determination of the economic impact.

1 Introduction

The Ministry for the Environment commissioned BERL, Lincoln University's Agribusiness and Economics Research Unit (AERU) and their associates Infometrics, National Research Bureau (NRB) and Otago University's Centre for the Study of Agriculture, Food and the Environment (CSAFE) to complete a study to determine the effect on New Zealand's clean green image (CGI) of the release into the environment of genetically modified organisms (GMOs), and the risks and opportunities to New Zealand's international trade and economy of such release.

The programme of work completed and rationale behind it is as follows.

The project conducted surveys in export markets and in New Zealand in the inbound tourist market to ascertain:

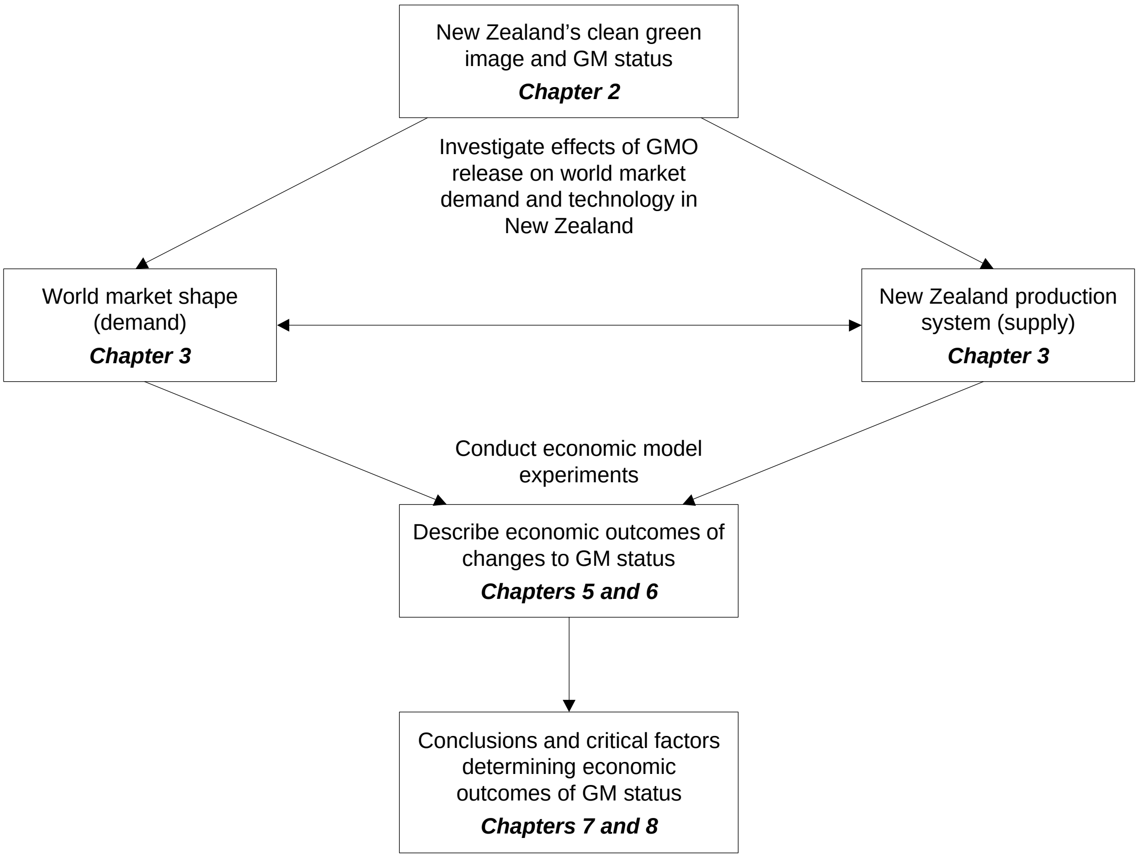
- the extent of New Zealand's CGI
- the effect that releasing GMOs affects New Zealand's CGI.

From this base the requirement is to determine by how much this affects the New Zealand economy.

As per the research brief:

> *"The purpose of this research is to study and report on two related areas.*
>
> *The prospect of the first release of a genetically modified organism into the New Zealand environment has significant environmental, social and economic implications. It has been claimed that a release of genetically modified organism in New Zealand (particularly a GMO crop) would tarnish our image and negatively affect our export sales (ie. our competitive advantage would suffer), especially if our clean green competitors were seen to retain or improve their environmental image by not undertaking genetic modification activities. Given this:*
>
> - *What would be the impacts (positive and negative) on New Zealand's competitive advantage in primary production if we release a GMO? The GMO could be a crop species, a pest biocontrol or a human medicine. Test the impact of all three GMO release types.*
> - *What would be the impacts on other export sectors (in particular inbound tourism) of the release of a GMO (crop, pest biocontrol and human medicine)?"*

The schema of analysis is as follows.



2 New Zealand's Clean Green Image and GM Status

The rationale for this project emerged from two semi-related strands of research in New Zealand: First, a body of work on our clean green image (CGI) and related issues of potential economic risks that might result from a diminishing of this image; second, the economic analysis of future deployment of GM in primary production, environmental remediation or medicine.

2.1 New Zealand's clean green image

The origins of the concept of a 'clean green' image for New Zealand are comparatively recent, commencing in the mid-1980s around the time of the Rainbow Warrior incident (1985) and the passing of the New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act (1987).

Not long after this, researchers began to investigate the CGI in terms of its marketing and consumer significance. The initial research was conducted by Gendall et al (1993) and related the CGI to nuclear free and broader environmental issues. Their report showed that the CGI had become a widely recognised concept among New Zealanders, but that 42% thought it was a myth.

Then followed two studies commissioned by the Ministry for the Environment (MfE) to evaluate the economic value of the CGI. The first was *Key Opportunities and Risks to New Zealand's Export Trade from Green Market Signals* (Woodward Clyde: Wellington, 1999). This report moved beyond the term CGI and argued that for economic analytical purposes what was being considered was green market signals that involved environmental criteria and trade access, eco-labelling, buyer pressure, 'gatekeeping' and consumer sentiment around food scares, risk, environmental criteria and food safety.

The second MfE-commissioned study was undertaken by PA Consulting Group (*Valuing New Zealand's Clean Green Image*, PA Consulting Group, 2001). It modelled effects of a hypothetically deteriorating environment on dairy exports and inbound tourism, and a GMO release on organic agriculture. The PA Consulting Group (2001) report suggested some important emergent issues for the economic impact of environmental image in primary production, but was only able to conduct a partial review of one aspect of primary production in New Zealand.

Clearly, New Zealand has a clean green image, and the PA report indicated that New Zealand's CGI has significant value in overseas markets. The relationship between release of genetically modified organisms (GMOs), our clean green image and export receipts has not been fully explored.

2.2 The economic analysis of GM in primary production

Given that prior to 1995, the use of GM in the production of various goods was both novel, and relatively uncontentious in New Zealand, it is not surprising that there was little analysis of the economic impacts of such use. The year 1999 saw the movement of UK and European supermarkets to impose restrictions on GM products, and the EU imposed a moratorium on new GM crops in European agriculture (CEC 2000). Since this emergence of adverse economic events for GM, a small body of economic analysis has begun to be undertaken in New Zealand around the potential impact of GM.

Analyses around the Royal Commission on GM included the Background Briefing Paper: *The Economics of Genetic Modification* prepared by Jan Wright. Secondly the Life Sciences Network commissioned Infometrics to provide a series of economy-wide model experiments on a range of scenarios relating to use or restriction on GM in the New Zealand economy (Stroombergen, 2000). The results were generally positive for GM, although some critical assumptions behind these findings were reviewed by BERL (Nana, 2000), concluding that more needed to be known about the demand-side assumptions. Thirdly there was the first presentation of results from the newly developed Lincoln Trade and Environment Model (LTEM). These findings were generally negative for the adoption of GM in primary production sectors. Saunders and Cagatay (2002) also argued that such model runs were preliminary, and needed further elaboration of assumptions and scenarios.

It is therefore appropriate that this present research effort is able to overcome some of the market survey data shortcomings of previous analyses and to analyse these using the Infometrics and BERL economy-wide models and the LTEM.

2.3 Issues making GM economically important to New Zealand

The two fundamental issues which make the ongoing decisions on releasing GMOs important to the New Zealand economy are that the potential risks and the potential opportunities presently attached to GM are cornerstones of the strength of the New Zealand economy. These specific risks and opportunities attach to adopting the GM technology, and specifically the release of GMOs.

Potential economic risks

Using GM technology in New Zealand, or releasing GMOs into the environment, could bring the risk that people in overseas markets would buy fewer New Zealand goods and services, or that New Zealand may lose access to certain export markets for some products. New Zealand's economic wealth is highly dependent on the sale of goods and services to people in overseas markets.

Potential economic opportunities

New Zealand's economic wealth is highly dependent upon the productive and environmental characteristics of plants and animals. GM can provide the opportunity to change some existing characteristics of these plants and animals, and to create entirely new products and sectors of economic activity.

Therefore New Zealand has potentially great economic risks and opportunities attached to the path it adopts on GM, though as outlined above, the relative newness of the technology means there is some uncertainty as to the present levels of costs and benefits. While the current world market for the first generation of GM food products is not positive, these products are generally not ones important to New Zealand's agricultural production, being soyabean, corn and canola. Other first generation GM products have been successful, particularly cotton and some animal feed products. There is, however, wide uncertainty as to the future possible costs and/or benefits as opinions and buying habits change and evolve, and as a second generation of GM products emerges which might have more attractive qualities for consumers. Similarly the opportunities for New Zealand will be different across food, fibre, and environmental and medical applications of the technology.

2.4 Approach to the analysis

The present analysis has the objectives to identify and where possible measure:

- the effect on New Zealand's CGI of releasing GMOs
- the economic risks and opportunities from the release of GMOs.

The rationale required is therefore to investigate:

- whether or not New Zealand has a CGI
- the potential effects releasing GMOs in New Zealand would have on New Zealand's CGI
- the risks and opportunities attached to releasing different types of GMOs, and the effects on the economy.

Because of uncertainties surrounding present and future potential risks, opportunities, costs and benefits, the chosen approach is to specify possible scenarios of risks and opportunities and to find the range of possible effects on the New Zealand economy.

By testing a range of sensitivities to reflect the uncertainty involved around the scenarios, the analysis will indicate the main critical factors that will determine whether the outcome of GMO release is likely to be positive or negative.

2.5 Risks and world market opinion

The base necessary to formulate an approach to assessing the economic risks attached to releasing different types of GMOs is to understand consumer perceptions of biotechnology, and the effects these have on purchasing patterns. These perceptions as of the end of 2000 are summarised in Campbell et al (2000). It considered 61 publications on consumer perceptions of biotechnology until that time. Since 2000, another 41 surveys and polls have been conducted and these have been reviewed and added to the findings of Campbell et al (2000). In general, surveys and opinion polls since 2000 have found similar results to those reported in 2000. The most significant development since 2000 is the first body of publications from the Public Perceptions of Agricultural Biotechnologies in Europe (PABE) project. The PABE project used a large number of intensive focus groups in numerous EU countries to elicit understandings about people's concerns and hopes for biotechnology.

There are two broad conclusions that can be drawn from this work. First, since around 1995/96 a segment of the market in many Western countries has developed negative attitudes towards GM food, with more tolerance or open encouragement for GM medicines and diagnostic technologies. Levels of trust and perceptions of risk associated with GM technologies are increasingly related to broader concerns about ethics, food morality, regulation and food safety, and the perceived politics of food trading.

The first conclusion therefore is that there is likely to be resistance to GM food (GMF) as a potential export product from New Zealand. This resistance in key markets has become relatively stable, and comprises a minority segment of some of our key markets. While a few opinion polls suggest a slight diminution of consumer concern, the overall picture across all the literature is that this segment is stable in its aversion to GMF.

The second conclusion, however, is that there is a degree of variability within these broad trends. While the PABE study identified some core issues shared across EU countries, there were also country-by-country differences. Europe's and Japan's consumers are generally less inclined to approve of GMF than those from US, Americas, Asia and Australia. Within each of the populations a range of opinions has been found, ranging from complete aversion to GMF to those who may prefer to buy GMF. There is also some research showing a changed response and increased acceptance of the GM technique following actual product experience of GMF.

There is a broad range of research information available as to, for example the increase in price consumers were willing to pay to avoid GM breakfast cereal – the average price increase was reported as 56% in UK and 37% in the US. In a comparison in the US Midwest of GM and non-GM foods like vegetable oil, corn chips, and potatoes, the consumers discounted the GM product by an average of 14%.

Levels of consumer concern also vary strongly by actual application of biotechnology. GM food is considered the most problematic, but other GM technologies like environmental remediation and medical uses have more ambiguous or, in some cases, positive consumer responses.

Alongside these different responses by consumers to either food or medical biotechnology, a significant aspect of world market risk is the actions of market gatekeepers, regulators, and retailers. The most significant negative effects experienced by US GM food exporters have been caused by EU moratoria on particular GM foods, and movement against GM foods by supermarket chains and co-operatives (CEC 2000). These actions are seen to have amplified consumer concerns around GM foods. They have not applied to medical technologies where research shows a high degree of consumer confidence in the regulation of medical products.

When consumer perceptions of the different applications of biotechnology are combined with differing regulatory regimes, it is clear that different dynamics are emerging both in each individual market and according to which application of GM is in question.

It is also worth noting that there is a complete absence of literature directly targeting the key issue in this research project: does the release of some GMOs in a country influence consumer buying behaviour for non-GM products from that country? This is a clear gap in the existing knowledge around GM, which provides a strong justification for the survey and modelling work undertaken in this project.

The project team working with the interdepartmental steering group therefore designed and conducted two surveys to find overall if New Zealand had, in consumers' eyes, a CGI and, if so, would New Zealand releasing GMOs significantly affect that image? If it did so, to what extent would that change carry through to changes in purchases of New Zealand goods and services? The first survey canvassed a limited number of consumers and 'gatekeepers' internationally in three main export markets, namely Australia, United Kingdom and United States. An additional survey, using the same questionnaire as for the first, interviewed international visitors to Christchurch.

2.6 Potential GMO opportunities

The potential opportunities for benefits from the release of a GMO range across the full gamut of plant and animal production, control of pests in the environment especially those of conservation importance, and human therapeutics. In the plant and animal production area, the potential opportunities include pest control, productivity increase and improving environmental impact of production by reducing herbicide and pesticide use, and reducing methane emissions from ruminant animals (cattle, sheep, goats, deer). The range of potential applications will differ in agriculture, horticulture, plantation forestry, aquaculture, and medicine.

The literature was reviewed to cover some of the key issues in relation to economic issues and GM. Specifically: the impacts of GM in primary production in the US, the level of grower adoption of GM, and studies of the trade performance of GM.

The reviewed literature was heavily weighted towards the economic issues of GM in primary production. Very little work has been done on the economics of GM in medical and pharmaceutical contexts, as the consumer and regulatory contexts for medical GM are quite similar to that for all pharmaceutical products. Thus, GM has not been isolated out for special economic evaluation. Similarly, there has been no attempt to evaluate the potential economic value of environmental products derived from GM. There is some discussion of the environmental impacts of new GM products in agriculture, but none that tries to evaluate a GM technology specifically designed for an environmental purpose (eg. to control a pest in the wider environment). This study is a step towards filling that gap.

Studies examining the performance of GM food crops in farm production have suggested that productivity gains are small, or even absent, but that farmers found the new technology more convenient or flexible to use. Some reports originating from interest groups or industry organisations either considerably enhance or detract from this performance. However, the key evaluations by the USDA adhere to this modest evaluation of productivity gains in food crops. The results are less ambiguous when evaluating environmental outcomes (although still contested by some groups) or when evaluating cotton (generally regarded as a non-food crop).

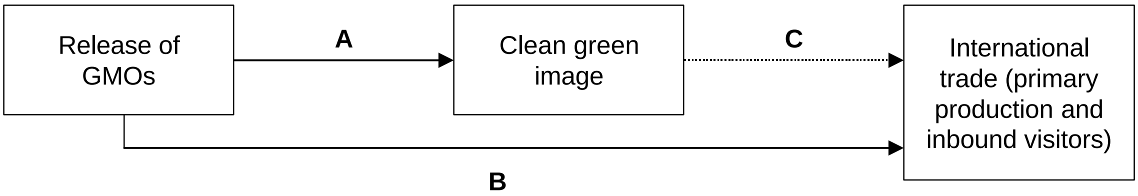
It is not possible to identify at this time all potential opportunities for the application of GM in New Zealand, nor to specify the economic effects and model the impact of them all on the New Zealand economy. What can be done is to identify a small number of types of GM opportunities, to specify a range of possible effects from each and model the outcomes to obtain 'order-of-magnitude' economic effects from these opportunities.

An interdepartmental steering group has identified the desirability of specifying and measuring the economic effects of three types of GMO, including: one that increases agricultural productivity, one that achieves pest control, and one with human therapeutic application. Analysis is also required of the economic effects of New Zealand foregoing the release of any GMOs.

The need is therefore to measure the potential effects each may have on New Zealand's CGI and on consumer purchasing in overseas markets, and also the effects which adoption of that type of GMO would have within the New Zealand economy.

3 Impact on New Zealand Image and Markets of GM Status

The diagram depicts the influences that are the focus of this study.



In particular, the demand-side survey of consumers, gatekeepers and visitors is attempting to measure the impact labelled 'A' (ie. the impact that the release of GMOs has on the CGI), as well as that labelled 'B' (ie. the impact that the release of GMOs has on New Zealand's international trade). By implication, we can then infer the influence labelled 'C'.

Furthermore, the economic modelling component of the survey attempts to measure the impact labelled 'B' (using, in part, the outputs from the demand-side survey, as well as information from the supply-side scenarios).

The overall layout of the questionnaire for the two consumer surveys comprised three sections:

- an initial section aimed at placing a range of countries, including New Zealand, along a five-step[1] 'relative image of the environment' spectrum
- a second section to determine by how much "the image of the state of the environment in New Zealand" may or may not change as a result of the release of certain (specified) GMOs
- a third section ascertaining the impact of the release of GMOs in New Zealand on foreigners' purchase intentions of New Zealand products and holidays.

The precise description of the scenarios specified in the second section was determined by the research team. There was considerable debate about the amount of information that was put 'in front of' respondents concerning the type, method, use and benefits and risks of the particular GMO being released. We have also been mindful of directions in the contract brief and comments from the Steering Group concerning the type of GMOs to be covered.[2]

As a result, there were two options:

- *either* specify the details of the GMO release but provide *no* information on either expected benefits or potential risks
- *or* specify the GMO release with additional information on expected benefits *and* potential risks.

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[1] That is, 'very good, among the best', 'good, above average', 'average', 'not good, below average', 'bad, among the worst'.

[2] In particular, the need to cover three different types of GMO release (ie. crop, pest-control and human medicine), as well as the requirement that the release be of 'live' GMOs.

Again, taking into account comments from peer reviewers on preliminary questionnaire drafts, the option to provide *no* information on expected benefits or potential risks was chosen. As a result, the 'scenario' specifications in the questionnaires were phrased according the following structure:

- state method or 'host organism' of GM technology
- state reason or aim of GM technology (the assumption is that the GM technology adopted is 'successful' in such an aim,[3] but the scenarios were silent on other effects, be they positive or negative)
- state mechanism by which it is applied/spread.

This approach allows the respondent to answer using all his/her inherent preferences and beliefs whether informed or otherwise. The parallel of business confidence surveys is useful. Respondents to such surveys are not fore-armed with information as to the current economic situation, prospects, influences et al, rather they respond given their *own* predetermined disposition to the current environment formed from their own knowledge, whether informed or otherwise.

At least two factors influencing survey results need to be borne in mind when generalising from scenarios as presented in a survey to 'real life'. The first relates to information at point-of-sale. It is unlikely that consumers would know, or bring-to-mind at point-of-sale, the GM attributes of New Zealand in other contexts, and yet in the survey context, of necessity, this has been brought specifically to their attention.

Secondly, the price-quality characteristics of the product, relative to those from other countries can assume a powerful if not predominant influence in the product choice for many consumers, including in particular trade-offs of immediate tangibles (cost, appeal) against intangible and more remote perceptions of other consideration like GMOs.

One type of consumer response is not sensitive to price but expresses an aversion to GM food that is categorical, a similar purchasing behaviour to vegetarians or consumers guided by religious codes.

Furthermore, the durability of the above figures will depend on the dissemination of favourable, unfavourable and neutral information about GMOs, and the way the public receives this. Repeat measures are appropriate in the relatively early phase of public understanding. In particular, it is common for people to be cautious about such innovations until sufficient time has elapsed for them to be proven.

A second area of influence is the degree to which stated attitudes are reflected in real purchasing behaviour. Choice modelling surveys (Burton et al, 2001; James and Burton, 2002; Kiesel et al, 2002; Noussair et al, 2001) showed that consumers were willing to pay more for non-GM food when all relevant information was available to them. However, Noussair et al (2001) also showed that during the experimental sessions, if information was not provided, most respondents failed to read the labels on the foods to discover whether they were GM or not.

[3] For example, the human medicine GMO question refers to use of a virus "that protects a person against a contagious disease". This was the stated aim of the GMO release in this case; the survey was silent as to whether such an aim was successful or not and was also silent on any other positive or negative impacts.

Another report (Grunert et al, 2002) indicated actual product experience could also impact on consumer preferences. They report a laboratory experiment where some consumers (whose cheese preferences had been earlier determined) were given cheese to taste. They were subsequently told the cheese was GM. The findings suggested that the positive experience with GM cheese made them less negative about GM foods overall.

In other words, it has to be acknowledged that there are many influences that determine purchase behaviour. Price is one of these influences. Amongst others is a wide spectrum of product characteristics integrated with buyer knowledge and taste preferences. In addition, these influences change across time as external events affect consumer behaviour.

For example, Gamble and Gunson (2002) report that genetic engineering was one of several food safety issues receiving ‘moderate ratings of concern’ in a phone survey in 2001. This level of concern fluctuated over the two time periods of the survey, possibly caused by receding memories of the BSE crisis.

However, this variability over time should not be overstated.

A review of 102 opinion polls since 1992 (see Appendix: Background and Literature Review) generally showed little shift in public sentiment about GM food since 1998 (although shifts took place in relation to other potential applications). In particular, the PABE (2001) study showed that consumer concerns were stable over time, but that they were influenced by the perceived past behaviour of market and regulatory institutions rather than the technology itself. This resulted in positive sentiment about GM medicine but not about GM food.

One official survey that has recorded reduced concern with a number of food characteristics is the UK Consumer Attitudes to Food Survey, conducted periodically by the UK Government’s Food Standards Agency. In the most recent report (2003) of the changes since 2000, the survey recorded a significant fall in those concerned about BSE (45% compared to 61% in 2000), as well as a significant reduction in those concerned about GM foods (36% compared to 43% in 2000).

A final influence on consumer behaviour is the effect of institutional purchasing decisions, market gatekeepers, and multiple retailer strategies. CEC (2000) documents the actions of multiple retailers as both ‘amplifying’ consumer concerns, and being the most economically damaging factor faced by food exporters to Europe. The actions of retailers in acting ‘on behalf’ of their consumers has had an important influence – sometimes taking the concerns of a minority of consumers and using them to create total lock-out of GM foods. This effect is highly variable across markets, with some markets (like the US) having little such activity, while others (Japan, UK, Germany) experience major influence from retailer and regulatory actions (CEC 2000). Furthermore, these gatekeepers are likely to be sensitive to distinctions between food, food inputs, medical and environmental applications of GM. The literature review suggests that gatekeeper effects are likely to be much lower for the latter of these GM applications.

In conclusion, the results of consumer surveys are subject to a range of influences that make it difficult to translate stated preferences into actual market effects. Some influences require an assessment of the ‘fading’ of stated preferences, while others ‘amplify’ consumer concerns out of proportion to stated results. Consequently, it is essential that all understandings of survey results be interpreted within the context of sophisticated knowledge of specific key markets.

3.1 International market survey results

This survey was undertaken by NRB. Detailed results are in the appendix document *NRB Survey consumer results*. A copy of the questionnaire is in the appendix document *Survey Questionnaire.*

A net sample of 444 people was interviewed on the basis of one per household. Interviews were conducted in three countries: Australia (150), United Kingdom (150) and United States (144). To focus the study on areas where New Zealand produce is thought to be more widely available, the following regions of each of these countries were sampled: Australia (all), United Kingdom (England), and United States (California, Oregon and Washington). A summary of results follows.

3.1.1 Relative image of the New Zealand environment

1. Respondents' image of the New Zealand environment was excellent, with approximately one-third of all respondents rating New Zealand 'very good, among the best', and a further 48% thinking New Zealand's environment 'good, above the average'.
2. New Zealand's environment was rated highly by respondents from all three countries, along with those of Switzerland and Canada.
3. The New Zealand environment was rated highest in the United Kingdom, where 41% of respondents thought it to be 'very good, among the best'.

Table 3.1: Image of the New Zealand environment

	Australia %	United Kingdom %	United States %	Total %
Very good – among the best	27	41	29	32
Good – above average	58	44	41	48
Average	9	8	9	9
Not good – below average	1	2	1	1
Bad – among the worst	1	–	–	–
No image	5	5	19	10

NB: Percentages may not add to 100 due to rounding.

3.1.2 Image change

Approximately 55% of respondents stated their image of the New Zealand environment either would not change or would improve should New Zealand release GMOs in pest control or livestock feed. Conversely, approximately one-third of all respondents stated that their image of the New Zealand environment would get worse in such a situation.

1. Respondents were more tolerant of the use of GMOs in disease prevention, with 68% of all respondents saying that New Zealand's environmental image would stay the same or improve. Conversely, 19% overall stated that their view of the New Zealand environment would worsen under this scenario.
2. One-third of the respondents stated that their image of the New Zealand environment would improve under a scenario in which New Zealand did not use GMOs, while over half said that their view would remain unchanged.

3. Respondents in the United Kingdom were most averse to New Zealand's use of GMOs, with 43% stating their image of the environment would worsen under the pest control scenario, and 51% stating this under the livestock feed scenario. However, 41% said their image of New Zealand's environment would improve should it use GMOs to prevent disease.

4. Australian and American respondents were more open to New Zealand's use of GMOs under the different scenarios.

Table 3.2: How respondents' image of the New Zealand environment would change under different GMO release scenarios

		Pest control %	Livestock feed %	Disease prevention %	No GMOs %
Get better	Australia	33	31	35	29
	United Kingdom	19	18	41	45
	United States	24	29	40	24
	Total	25	26	39	33
Stay the same	Australia	30	27	32	59
	United Kingdom	27	23	27	44
	United States	30	37	29	58
	Total	29	29	29	54
Get worse	Australia	27	34	21	8
	United Kingdom	43	51	17	3
	United States	27	24	18	8
	Total	32	37	19	6
Don't know	Australia	10	8	12	4
	United Kingdom	11	7	15	8
	United States	19	10	13	10
	Total	14	9	13	7

NB: Percentages may not add to 100 due to rounding.

3.1.3 Purchase change

1. When confronted with a scenario in which the respondent was choosing a non-GM product that came from New Zealand, which used genetic modification (GM) in other ways, the majority of respondents said they would feel no different to before. This accounted for 43% of all respondents in the fruit scenario and 54% of respondents under the dairy products scenario.[4]

2. Between one-quarter and one-third of respondents said they would be less inclined to purchase the product under the fruit and dairy scenarios. Of these respondents, the majority stated that would not buy the product regardless of any discount applied.

3. Respondents appeared more comfortable buying a dairy product from New Zealand should it use GM, than they were purchasing fruit, with fewer respondents less inclined to make such a purchase.

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[4] That is, where the product in question was fruit 'from New Zealand and some other countries', or 'dairy products from New Zealand as well as from other countries'.

4. When choosing a holiday, respondents were less likely to be affected by New Zealand's GM status, with 72% overall stating that they would feel no different about choosing a New Zealand holiday should New Zealand use GM.

5. Respondents reacted far more favourably to a scenario in which New Zealand did not use GMOs. A group of 47% stated that they would be more inclined to buy New Zealand fruit, and another 43% stated it would make no difference. The majority of the 47% of respondents who stated they were more inclined to buy remain prepared to buy this product when a price premium was applied.

Table 3.3: How respondents' purchasing behaviour would change under different GMO release scenarios

		Purchasing fruit %	Choosing holiday %	Purchasing dairy produce %	No GMOs %
More inclined	Australia	14	11	13	45
	United Kingdom	6	7	7	55
	United States	16	9	11	40
	Total	12	9	11	47
No different	Australia	43	73	58	47
	United Kingdom	41	65	47	33
	United States	44	77	57	49
	Total	43	72	54	43
Less inclined	Australia	36	13	25	2
	United Kingdom	37	13	32	1
	United States	30	11	26	4
	Total	35	12	28	2
Depends on product	Australia	7	4	4	6
	United Kingdom	16	14	13	11
	United States	10	3	6	6
	Total	11	7	8	8

NB: Percentages may not add to 100 due to rounding.

3.2 Inbound tourist survey results

An additional survey, using exactly the same questionnaire as for the above survey, interviewed 93 international visitors to Christchurch. Interviews were conducted during December 2002 and the sample was matched to the characteristics of international visitors to New Zealand. Summary results follow. Detailed results are in the appendix document *Lincoln survey results*.

3.2.1 Image of New Zealand environment

1. Most respondents (99%) stated they had an image of the New Zealand environment that was either very good (among the best) or good (above average).

2. Possible sample bias in terms of the 'be kind to host' effect, is acknowledged here. The resulting data may reflect more positive assessments compared to the international market survey results.

3. Switzerland and Canada also scored highly, with 54% of respondents rating Switzerland as 'very good, among the best'. There were 52% who rated Canada's image as 'very good, among the best'.

Table 3.4: Image of the New Zealand environment

	Total %
Very good – among the best	52
Good – above average	47
Average	1
Not good – below average	–
Bad – among the worst	–
No image	–

NB: Percentages may not add to 100 due to rounding.

3.2.2 Image change

1. Over one half of the respondents stated their image of New Zealand's environment would stay the same should New Zealand release a livestock feed or pest control GMO. 23% of respondents stated their image of New Zealand's environment would get worse.

2. Respondents were less tolerant of the use of GMOs in disease prevention with 33% stating that their image of the New Zealand environment would worsen in this event.

3. 47% of respondents stated that their image of the New Zealand environment would stay the same under a scenario in which New Zealand did not use GMOs, balanced by 45% who stated their image would improve.

Table 3.5: How respondents' image of the New Zealand environment would change under different scenarios

	Pest control %	Livestock feed %	Disease prevention %	No GMOs %
Get a lot worse	2	3	15	–
Get a little worse	21	20	18	2
Stay the same	52	56	40	47
Get a little better	8	3	10	27
Get a lot better	4	3	4	18
Don't know/can't say	13	14	13	5
Total	100	100	100	100

NB: Percentages may not add to 100 due to rounding.

3.2.3 Purchase change

1. For each GMO scenario considered, just over one quarter stated that they would be less inclined to purchase New Zealand products or holidays, and over one half stated that their purchasing behaviour would be no different.
2. For the scenario where New Zealand did not use GMOs, 57% stated that they would be more inclined to purchase products from New Zealand.

Table 3.6: How respondents' purchasing behaviour would change under different scenarios

	Purchasing fruit %	Choosing holiday %	Purchasing dairy produce %	No GMOs %
More inclined	0	1	0	57
No different	56	63	57	32
Less inclined	26	24	26	3
Depends on product	18	12	17	7

NB: Percentages may not add to 100 due to rounding.

Information from both of these market surveys was used to determine two direct inputs into the economy-wide model experiments reported in the next section. These two inputs were:

- the magnitude of the shift in the export demand curves facing New Zealand exporters
- the sensitivity of demand to changes in price.

An outline of the calculations involved in translating the survey results into these two model inputs is provided in the following two sections. Additional detail is provided in the *Model Experiments* appendix.

3.3 Translating the survey results to model inputs: demand changes

The NRB survey results of respondents across the three countries (Australia, US and UK), along with the Lincoln survey results of visitors' responses, were extrapolated to apply to all New Zealand export markets for dairy, meat, horticulture and tourism. The translation of these results to model input assumptions is outlined below.

3.3.1 GMO scenarios

Various questions surveyed the change in purchasing behaviour upon the introduction of a GMO in New Zealand. From responses, the calculated average price – 'willing to pay' – for New Zealand products *amongst those that remain in the market*, was almost unchanged.

That is, amongst those that responded that they might continue to purchase New Zealand products, there were some who would buy only if the price was lower than before and there were others who remained prepared to buy at a higher price. Upon calculation, it was clear that the influences from these two groups of consumers – following the release of a GMO in New Zealand – in effect, 'balanced each other out'.

In other words – amongst consumers that continue to exhibit a demand for New Zealand products – the balance between those consumers willing to pay a higher price and those requiring a lower price to purchase New Zealand products is close to evenly matched.

On the basis of these results, the surveys indicated that the 'horizontal' shift of the demand curve facing New Zealand exporters (as depicted in Figure 3.1 below) of dairy, meat, horticulture and tourism is almost wholly identified by those that 'withdraw totally from the market' upon the introduction of GMOs in New Zealand. By 'withdrawing totally from the market', we mean that they responded to the survey questions with the statement that there was no price at which they would purchase New Zealand products subsequent to New Zealand releasing GMOs.

The figures for those that withdraw totally from the market are given in Table 3.7 below for each of the purchase change questions in the two surveys. The NRB survey responses by country were averaged using trade weights derived from trade data over the past two years.

Table 3.7: Proportion (%) responding 'less inclined to buy and that a price change would make no difference'

	NRB survey data				Lincoln survey of tourists
	Australia	United Kingdom	USA	Weighted average	
Fruit purchase Less inclined to buy and price change makes no difference (%)	27	30	20	25.7	13
Dairy purchase Less inclined to buy and price change makes no difference (%)	21	29	21	23.3	5
Holiday purchase Less inclined to buy and price change makes no difference (%)	9	6	5	6.8	1

From the NRB survey for example, an average of 25.7% of respondents across the three countries said they were less inclined to buy New Zealand fruit and that price changes would make no difference. From the Lincoln survey, this proportion was 13%.

The resulting 'weighted average' figures from the NRB survey were then combined with the numbers from the Lincoln survey using 80%:20% proportions respectively.[5] The overall figures were a -23.2% shift in fruit purchase demand, -19.6 for dairy and -5.7% for holidays.

These figures were then adjusted to allow for the significant component of New Zealand dairy and meat exports not sold directly to consumers. Furthermore, following industry consultation, this component is not identifiable as New Zealand-made product but, rather, as ingredients or component inputs into other commodities. It is estimated that 40% of New Zealand's dairy exports and 45% of New Zealand's meat exports are 'open to a direct consumer' response. As such, the above shifts were translated into representing the horizontal shift in demand curves upon the introduction of GMOs, as listed in Table 3.8.

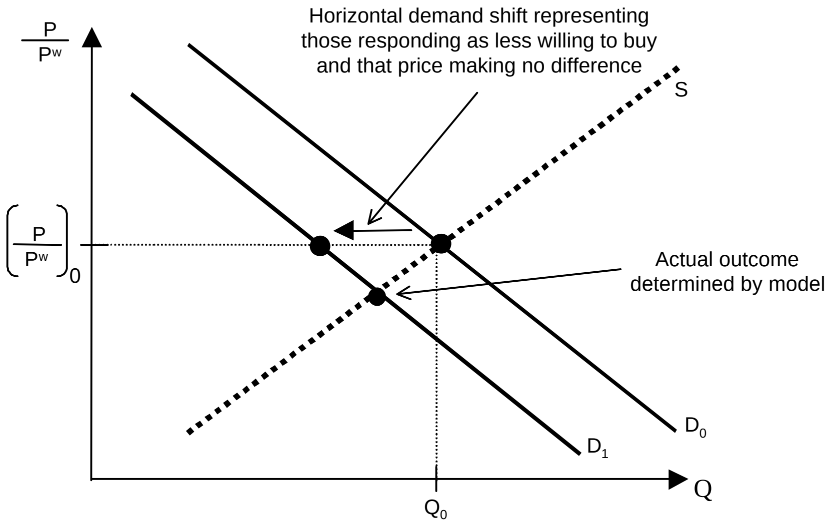
[5] Based loosely on the overall sample sizes of each survey, ie. 444 and 93.

Table 3.8: Assumed demand curve shifts (horizontal) with GMO release

% shift in demand curve	% open to consumer response	For CRP and PST scenarios		For HUM scenarios	
		From survey	Input to model	From survey	Input to model
Dairy exports	40	-19.6	-7.8	-9.8	-3.9
Meat exports	45	-19.6	-8.8	-9.8	-4.4
Horticulture exports	100	-23.2	-23.2	-11.6	-11.6
Tourism exports	100	-5.7	-5.7	-2.9	-2.9

Notes:
CRP = scenarios involving the release of a crop-based GMO.
PST = scenarios involving the release of a pest or biocontrol GMO.
HUM = scenarios involving the release of a human medicine GMO.

Figure 3.1: Shift in export demand following release of GMOs



where P = price of New Zealand export commodity

P^w = price of competing export commodity produced elsewhere

D_0 = foreign demand curve facing New Zealand exporters before release of GMOs

Q_0 = the level of New Zealand export volumes before release of GMOs

D_1 = foreign demand curve facing New Zealand exporters after release of GMOs based on survey response adjusted for proportion of exports 'open to consumer response'

3.3.2 No GMO scenarios

In the case of no GMOs in New Zealand, the average prices willing to be paid by *those that remained in the market* were significantly above those of the base case. This can be interpreted as a vertical shift of the export demand curve faced by New Zealand exporters.

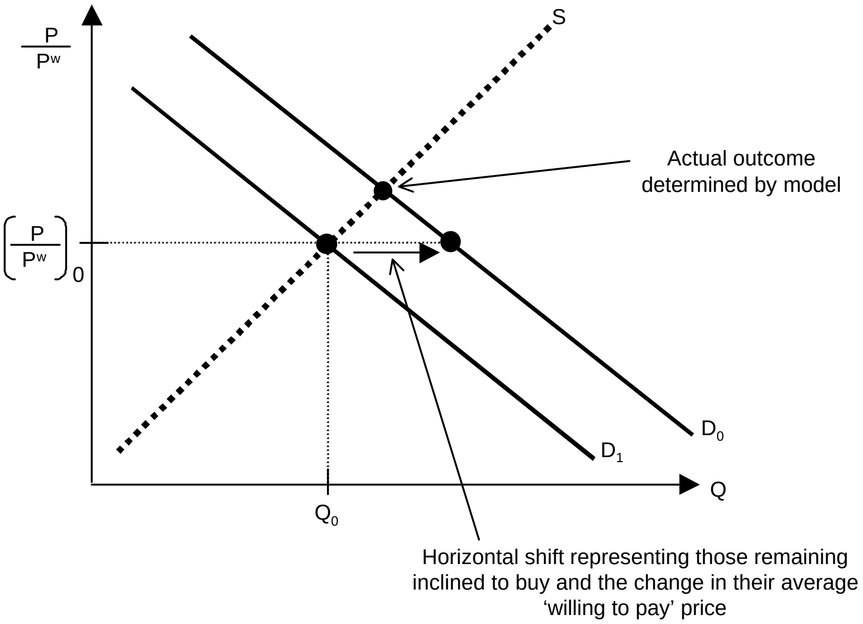
The horizontal shift consistent with such a movement was calculated. Figures from the two surveys were combined (using the 80%:20% proportions as above) to determine the overall demand curve shift of 34.3%. These were imposed in the 'no GMOs' scenarios, after adjustments to allow for the proportions of dairy and meat exports 'open to a consumer response', as per Table 3.9 below.

Table 3.9: Shift in demand curve facing New Zealand exporters given no GMOs scenario

% shift in export demand curve	% open to consumer response	for NOG scenarios	
		from survey	input to model
Dairy exports	40	34.3	13.7
Meat exports	45	34.3	15.4
Horticulture exports	100	34.3	34.3
Tourism exports	100	34.3	34.3

Note: NOG = scenarios where there are no GMOs in New Zealand.

Figure 3.2: Shift in export demand where New Zealand refrains from using GMOs



3.3.3 Note on human medicine scenarios

The shifts imposed for the PST, CRP and NOG simulations follow from the calculations described in the previous two sub-sections. The shifts imposed for the HUM simulations are half those imposed for the PST and CRP simulations. This is imposed on the basis that the responses to the image change questions indicated an order of magnitude difference in the expressed attitudes towards human medicine GMOs on the one hand and pest control and crop GMOs on the other. This difference is summarised in Tables 3.10 and 3.11.

Table 3.10: Effect on New Zealand's image if there was a release of GMO : NRB survey

	Pest control GMO %	Crop GMO %	Human medicine GMO %
Get better	25.3	26.0	38.7
Get worse	32.3	36.3	18.7

Table 3.11: Effect on New Zealand's image if there was a release of a GMO : Lincoln survey

	Pest control GMO %	Crop GMO %	Human medicine GMO %
Get better	12	6	14
Get worse	23	23	33

3.4 Translating the survey results to model inputs: sensitivity to price changes

Within the survey questions, respondents were asked whether or not their purchase decisions would change in the face of price changes. From the responses to these questions we obtained a set of 15 observations[6] concerning price and demand changes associated with purchases of each of New Zealand fruit, New Zealand dairy & meat and New Zealand holidays.

These observations were deduced from the set of consumers that 'remained' in the market. For example, a total of 10% of Australian respondents were less inclined to purchase New Zealand fruit upon the release of GMOs, but still signalled a willingness to alter their response if there was any price change. In particular, a 10% price reduction resulted in the proportion that remained less inclined to purchase falling from 10% to 7%. This increase of 3% out of a total o10% (ie. a 30% change) in the face of a 10% price change implies a 'sensitivity to price change' of 3.[7]

Calculations across the 15 observations for each of the three commodities provided estimates of the magnitude of such 'sensitivity' ranging from 1.4 to 7.5. Furthermore, the majority (ie. 33 out of 45) of these estimates lay in the range 2.5 to 5.0. In addition weighted average of the estimates suggested sensitivity of 3.8, 3.9 and 3.6 for horticulture, dairy and holidays respectively. Taking these calculations into account, the model experiments were undertaken using a price sensitivity equal to 4.0 for New Zealand exports of each of the dairy, meat, horticulture and tourism categories.

Table 3.12: Export demand sensitivity (elasticity)

Dairy exports	4.0
Meat exports	4.0
Horticulture exports	4.0
Tourism exports	4.0

[6] One observation being a combination 'change-in-price, change-in-quantity' pair. As a result of the responses gained from the in-bound tourist survey, estimates could only be based on three observations in each of the product categories. As such, it was decided to use the NRB information only, in the above calculations.

[7] This 'sensitivity' is formally termed the 'price elasticity of demand' and is defined as the percentage change in quantity demanded divided by the percentage change in price.

4 New Zealand's Production System

The adoption of policies to allow the managed release of GMOs that have been tested and legally approved as safe, provides the opportunity to continue and significantly extend the process of genetic improvement in New Zealand's biota-based production industries, as well as other improvements to production in New Zealand.

Genetic improvement has already enabled New Zealand producers to achieve significant productivity gains, and the use of GM technology can take this further. In pastoral agriculture, cropping, horticulture and forestry, GM may allow producers to control pests and reduce pesticide use, thereby achieving economic and environmental benefits. GM may also allow the production of further medicinal remedies to improve human health and wellbeing. These three types of effects are modelled in scenarios specified in this section.

4.1 GM application globally

Internationally GM has to date been applied mainly in production, and mainly in agriculture, being largely limited to arable field crops like soyabean, corn, cotton, canola, and potatoes. These crops have generally had genes introduced to help them resist attack by pests like insects; to resist pathogens like viruses; or have made them tolerant to a relatively benign herbicide to allow farmers to cease using more toxic herbicides which are expensive and leave residues. While there has been wide adoption of GM crops by farmers in countries such as US, Argentina, Canada, China, and South Africa, there is ongoing debate by researchers as to the extent to which these GM field crops achieve higher productivity, environmental benefits, and higher returns to farmers (USDA 2002).

The adoption of crop GMOs continues to increase on a global basis. The area planted was only 1.7 million hectares (ha) in 1996 and increased to 52.6 million ha in 2001, planted by 5.5 million farmers (ISAAA 2002). Recent reports indicate plantings of 57 million ha in 2002.

There is the potential for application of the same GM-induced pest resistance and herbicide tolerance to other field crops, fruit and vegetables. A report by the US National Center for Food and Agricultural Policy (2002) analysed 40 case studies of 27 crops that are either approved or under development. Of these 27 crops, 17 are crops of which conventional varieties are presently grown commercially in New Zealand. This indicates the potential range of opportunities that could be available for cropping in future should New Zealand allow release of GMOs into production.

4.2 GM opportunities in production

This section reviews the opportunities for GM in primary production, pest control and human therapeutics, and selects and specifies scenarios for testing. The first is in regard to agricultural production.

4.2.1 Opportunities for GM-enhanced agricultural production in New Zealand

The potential opportunities to enhance production in New Zealand from GM in the plant and animal production area include pest control, productivity increase, reducing any adverse environmental impact of production by reducing herbicide and pesticide use, and reducing methane emissions from ruminant animals (cattle, sheep, goats, deer). The range of potential applications will differ between agriculture, horticulture, plantation forestry and aquaculture.

It is not possible to identify at this time all potential opportunities for the application of GM, nor to specify the economic effects and model the impact all of them on the New Zealand economy. What can be done is to identify a small number of types of GM applications, to specify a range of possible effects from each and model the outcomes to obtain order-of-magnitude economic effects from these opportunities.

While the major application to date of GM technology globally is in arable field crop production, the more important potential applications in New Zealand are expected to centre on the two largest biota-based industries of pastoral agriculture and plantation forestry.

There are certainly opportunities in plantation forestry, and successful GM applications to improve the soil-plant-climate relationship to increase productivity could have significant economic benefits. However the pastoral agriculture production system has a larger number of organisms involved in the production system and therefore could offer a broader range of GM opportunities to enhance productivity over time.

For this reason the scenario selected to test for potential economic impact from production GMOs is based on pastoral agriculture. The scenario developed is called the 'Ryegrass scenario' but this is purely shorthand for possible GM applications within pastoral agriculture.

4.2.2 Historical performance of genetic improvement in pastoral agriculture

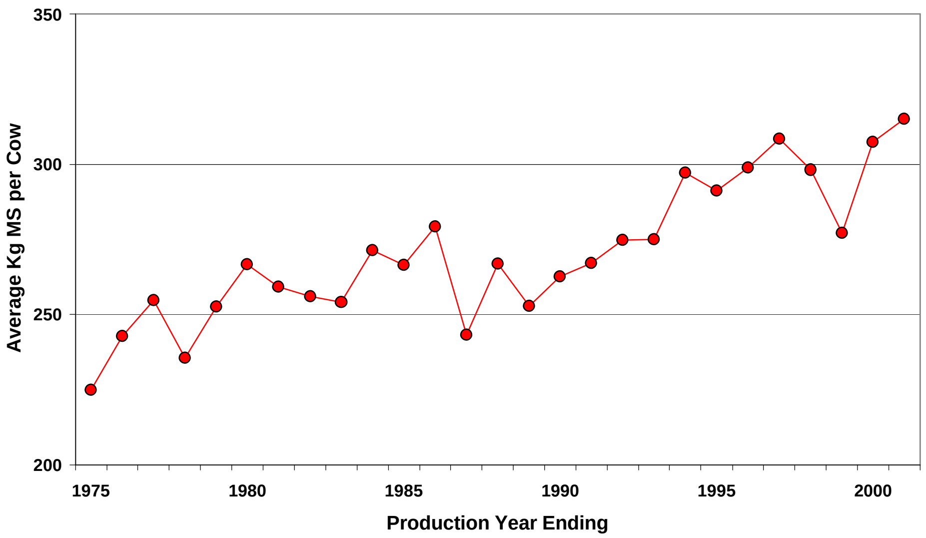
In New Zealand pastoral agriculture, genetic improvement has been pursued from soon after the importation of exotic species for agricultural production in the nineteenth century. Producers have utilised techniques like cross-breeding and selection to generate modified exotic breeds better-suited to the New Zealand productive environment, like Corriedale, Perendale and Coopworth sheep, a range of ryegrasses and some legumes.

Improvements in productivity in agriculture in the past have been estimated generally to lie in the range 1% to 3% per annum in the long term. Over a reasonably long term, ie. 1975 to 2001, average production per cow in the New Zealand dairy herd increased at about 1% per annum (the trend in the graph being an annual increase of 2.76 kg milk solids per cow over this 26-year period) (Dairy Statistics, Livestock Improvement Corporation Ltd, various dates).

There has been ongoing genetic improvement for decades through herd-testing and sire selection for artificial insemination sires. This has only achieved a moderate increase in productivity per cow of 1% per annum. Productivity per cow may have been adversely affected by increased stocking rates, and may have been improved by nutrition and other factors, so the increase is not all due to breeding, selection and genetics.

Animal selection can be improved using modern techniques like gene mapping, gene identification and marker-assisted selection. These techniques do not allow ready introduction of characteristics available from other similar species, and it is here that GM can allow significant and more rapid progress.

Figure 4.1: New Zealand average dairy cow productivity, 1975–2001



4.2.3 Potential for pastoral productivity improvement

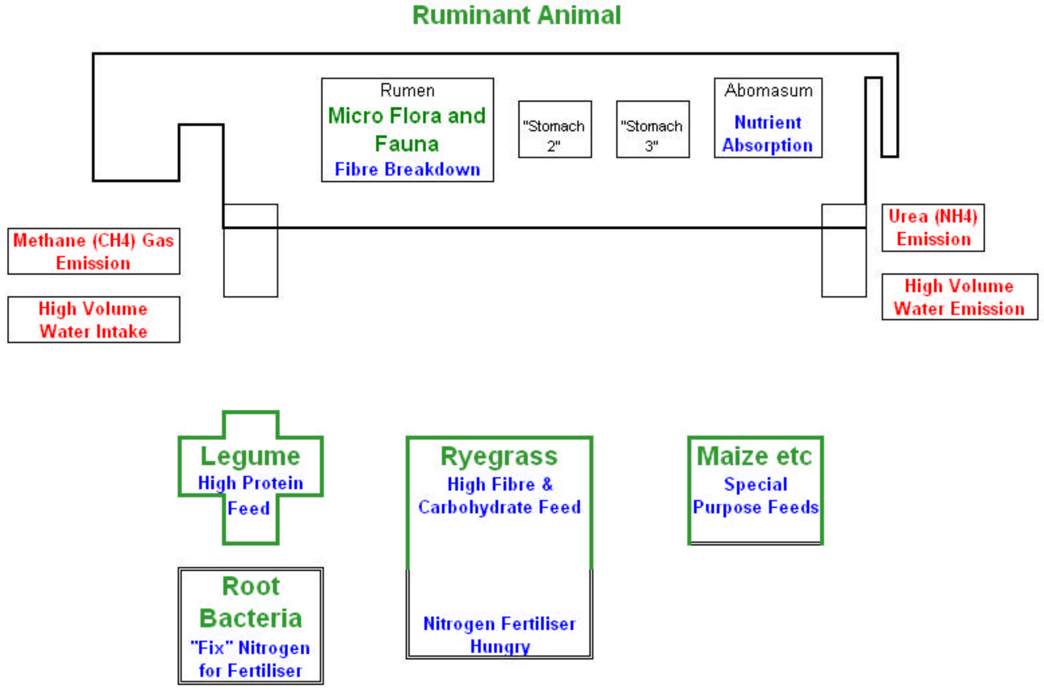
Pastoral agriculture is based on production from a system utilising both plants and animals that interact in a complex production system. The main plant and animal organisms and their functions are stylised in Figure 4.2 below.

There are significant opportunities and risks to increase productive output and to mitigate adverse environmental impacts by modifying the plants, the animals, and the processes in the pastoral production system using various genetic GM techniques.

Because of the range of organisms and processes contributing to the efficiency and other characteristics of the New Zealand pastoral agricultural production system, there has in the past been a range of genetic improvements and scientific discoveries (such as trace element deficiencies) relevant to some plants and animals in the system. These advances have been integrated with pasture and grazing management to increase the productivity of the system. The opportunity for GM to be applied to any or all of these organisms could allow future, significant, frequent and ongoing increments to productivity in the overall pastoral system.

In the GM arena, the base case scenario involves the adoption in New Zealand of technology and productivity as per historical trends (including, for example, marker-assisted selection); as well as the importation and use of seeds consistent with testing and tolerance criteria as per the year 1998.

Figure 4.2: Main organisms and processes in the New Zealand pastoral agricultural production system



4.2.4 The pastoral GMO scenarios

While potential opportunities for productivity increases based on GM exist in the pastoral agriculture system, it would be wrong to imply that there are now available substantially developed GM technologies that could be applied in pastoral agriculture should New Zealand decide to adopt GM technology.

However some work has been done, and there is a range of ongoing pastoral research, some elements of which may offer strong GM-induced opportunities to increase productivity. Since this study aims to measure economic impact, the main effect of future GM opportunities of interest is the productivity increases (if any) that could be expected.

Again because there are no specific advances in immediate prospect, the objective with this first scenario is to postulate a range of productivity changes that may be possible and the level of adoption one could expect to be achieved.

Productivity increases possible for individual elements in the pastoral process may be quite high, but must be considered in terms of the complete production system. For example, a productivity increase of up to 60% has been postulated for GM ryegrass, but it is highly unlikely that this level of increase would carry through to the productivity of the whole system in terms of production per cow, production per ha., and to economic productivity of cost per kilogram of meat or milk solids.

In recent pastoral research, a certain legume, *Lotus corniculatus* (birdsfoot trefoil), was shown to contain significant levels of chemicals called condensed tannins. These chemicals were shown to affect cows' metabolism resulting in increased production of milksolids per cow per day by 18%. If the characteristic of containing this chemical could be induced by GM into white clover, New Zealand's main pastoral legume, then presumably an increase in productivity of this order could be possible from GM clover pastures.

Another approach to thinking of the order-of-magnitude of productivity increases is the historical factor that breeding has generally resulted in increases in productivity of 1% to 3% per annum. It could be postulated as reasonable that GM applied to the pastoral production system might achieve productivity increases per annum within that range over a period.

The initial scenario is a GM-induced improvement to one component, say ryegrass, with an assumed productivity increase of 2.5% per annum. It is assumed that the uptake of the GM technology would be 50% within pastoral agriculture, and that this advantage (over the Rest of the World, or RoW) would be maintained for five years. This results by year 10 in an increase in the average productivity in pastoral agriculture of 6.4%. This scenario is called *Ref #2.*

These reference numbers are the labels for the experiments carried out using the economy-wide model. They are shown at the top of the relevant columns in the tables of results of these experiments in section 4.

The second approach is to assume that a range of ongoing incremental improvements are made such that the advantage gained from the induced productivity improvements of 2.5% per annum with an uptake of 50% is maintained over the 10-year period. This scenario is *Ref #3*. The 'counter-factual' or '*control*' approach on the pastoral productivity is to assume that there is no productivity increase, but that the negative effects on demand in the world markets as a result of the GMO release remain. This is called *Ref #1*. Finally there is the counter-factual or '*control*' on the demand side, assuming that productivity is improved as in *Ref #3*, but with no demand shift for or against New Zealand products. This scenario is *Ref #6.*

4.3 The pest control scenario

The second scenario tested in this study concerns a GMO possum control. Possum control is a key concern for New Zealand agriculture, because of grazing loss and primarily because possums are a vector for bovine tuberculosis. Possum control is also important for conservation, but this is not covered in this study. Bovine tuberculosis is estimated to afflict about 1.3% of cattle herds on a period prevalence basis, ie. at any given point in time about 1.3% of herds have bovine tuberculosis. For dairy cattle this implies that approximately 7% of animals become infected over their lifetime. However, about 12% of animals must be killed as they are deemed to be infected as a result of testing.

The incidence of bovine Tb in New Zealand is currently about six times higher than the guidelines prescribed by the Office Internationale Epizooties (OIE), used by the World Trade Organisation. The fact that we still export to Europe, US, Japan and other high value markets is primarily attributable to our high standards of meat inspection and pasteurisation. However, there is always a danger that consumer sentiment will turn against products from any country with a higher than acceptable incidence of bovine Tb.

The Animal Health Board provided some of the costs relevant to an economic evaluation of possum control:

- Current national expenditure on Tb possum control is $50–$55 million per annum. The Animal Health Board estimates that this expenditure needs to be sustained until 2013 for New Zealand to meet the OIE/WTO standard for Official Freedom from bovine Tb (infected herd prevalence less than 0.2%). Expenditure of $20–$30 million per annum is likely to be required thereafter to maintain official freedom status.
- Loss of agricultural and forestry production, plus damage to plantings for erosion control is estimated at $40 million per annum.
- Other expenditure on managing bovine tuberculosis (eg. Tb testing of herds) is $22 million per annum.
- On-farm costs of $22 million pa.

These costs total around $130 million per annum relating to possum control in agriculture and plantation forestry, providing a minimum benchmark against which the application of GM technology to controlling bovine Tb may be evaluated. In fact this benchmark may be much too low, as the whole of New Zealand's dairy and beef exports are potentially at risk. So even if GM based methods of controlling bovine Tb are not cheaper than current methods, if they provide more effective control and lower the risk to New Zealand's exports, there could be a greater net benefit that with present methods.

Two possibilities have been suggested: GM-based fertility control and GM vaccines. The former is aimed directly at possum physiology, the latter at a micro-organism. Both could be distributed by using a possum-specific parasite (nematode) as a vector. Fertility control is considered unlikely to be viable for another five to 10 years, but a Tb vaccine is probably viable within 2–5 years.

Funding under the Public Good Science Fund for research on possum control was $14.8 million in 1999/00 and has been at similar levels for the last five years, although not all of this is targeted purely at the control of Tb. Fewer possums would also have environmental benefits.

For modelling purposes it is assumed that a GM-based vaccine for the control of Tb in possums will be in common use by 2010 in dairying areas afflicted by Tb. This scenario is simulated as:

- a saving in expenditure on managing bovine Tb and on existing methods of possum control of approximately $50 million per annum
- an assumed cost recovery by the model's 'GM research' industry of 10% of this saving
- ongoing research and development costs of at least $25 million per annum over 2005–2010
- by 2010, a 6% increase in dairy output due to lower culling rates (this assumes that the incidence of bovine Tb is reduced by one-half, and the scenario is *Ref #4*)
- by 2010, a 12% increase in dairy output due to lower culling rates (this assumes that the GMO has been fully successful in eliminating the incidence of bovine Tb, the scenario is *Ref #5*).

4.4 Human therapeutics scenario

A number of current research projects in biotechnology and GM relate to human health. Examples are the production of a-1-antitrypsin in sheep or cattle for the treatment of cystic fibrosis, the production of A2 milk to reduce the risk of heart disease, and better ways of treating certain types of diabetes. From a modelling point of view these are all difficult examples to work with because the costs and benefits are too vague at this stage – for various reasons such as commercial secrecy or imprecise cause and effect relationships.

A more promising development is the research being undertaken by AgResearch to produce proteins for use in enzyme replacement therapy (ERT) for the treatment of lysosomal diseases which cause skeletal, muscular and neurological problems. There are more than 40 known lysosomal disorders, but ERT is available for only two or three of them. The proteins themselves do not consist of a live GM organism, but AgResearch is intending to produce them via transgenic cows. Their research is estimated to cost around $5 million per annum. The proteins are currently made in laboratories, but manufacture via cows is estimated to be around 1000 times more efficient.

AgResearch's aim is to produce more than 100 kg of proteins annually. At a value of more than $100/mg, export earnings could potentially exceed $10 billion. Whether such a high unit price can be sustained in the presence of large amounts of product made at much lower cost is certainly questionable. Nevertheless it is clear that export earnings measured in the hundreds of millions is a plausible scenario.

Note too that New Zealand is likely to retain an advantage in the production of these proteins for some time, as proteins produced from cows will not gain worldwide acceptance for human use, unless the source country is free from BSE. Our main competitor is likely to be Australia.

For modelling purposes it is assumed that between 2005 and 2010 there is a strong export market for proteins derived from transgenic cows for use in ERT in the treatment of lysosomal disorders.

Specifically this scenario is simulated as:

- export earnings of $200 million per annum
- ongoing research and development costs of $5 million per annum.

4.5 New Zealand refrains from releasing GMOs scenario

This scenario postulates a 'GM-free' New Zealand, while the Rest of World (RoW) pursues GM technology. We acknowledge the difficulty in defining the 'GM free' label, but in this context we interpret it (as per the survey questionnaire) to mean "New Zealand was not to use genetically modified organisms in production, nor release GM organisms into the environment". In other words, the "moratorium" remains in terms of applicants being able to apply to release GMOs for animal medicines and human medicines, and for emergencies.

On the demand side it is then assumed that some of New Zealand's exports would be able to attract a price premium, being traded in the GM-free market. The effect of this demand premium is shown in experiment *Ref #7*.

The main effect on production in New Zealand would be felt in the biota-based industries. Firstly the productivity of the producers in the RoW would increase, making them more competitive with New Zealand producers in general markets (ie. those markets which include GM products). To retain some consistency with the GM scenarios above, the productivity increase assumed in the RoW is 6.4% in total over the 10-year time horizon. This scenario is experiment *Ref #8.*

In addition to foregoing access to the RoW GM-induced productivity, the retention of GM-free status would first require New Zealand put in place infrastructure to ensure no importation of GMOs. If New Zealand took a purist stance to its GM-free status, and assuming the RoW had adopted GMOs, it would therefore be very difficult to import to New Zealand genetic material for breeding or for use in production as such material could be contaminated with GMOs.

The plant and animal species used in almost all of New Zealand's production for export are exotic species, namely cattle, sheep, deer, ryegrass, legumes, other pasture and feedcrop species, horticulture crops and *Pinus radiata*. New Zealand would be cut off from the source gene pool for genetic improvement of its production base. The isolation from world genetic improvement implies that New Zealand producers would not participate in the long-term trend increase in productivity due to cross breeding and selection within the world gene pool. This trend has been found to be 1% to 3% per annum. Lack of access implies that New Zealand genetic productivity in those industries would remain at present levels, foregoing the normal trend increase. This scenario could thus see the relative productivity of the RoW producers increase by the first 6.4% due to their adoption of GMOs, and a second, say, 6.4% compared with New Zealand producers due to the normal trend genetic selection and improvement over the 10-year time horizon. Due to genetic isolation, New Zealand could no longer participate in this second increase either. The overall effect would be a total of 12.8% relative productivity increase by RoW. This scenario is experiment *Ref #9.*

The results of these scenario model experiments are given in the following section.

5 Economy-Wide Model Experiments

5.1 The model

5.1.1 The economic relationships

Economic models represent the major relationships between the various sectors and participants in an economy. These relationships are expressed as equations and together form a coherent – but necessarily simplified – portrayal of the workings of an economy.

The particular model used here mimics the outcome of a 'balancing act' between the demands for goods and services and the resources necessary to produce those goods and services to satisfy such demands. The main relationships captured by the model are depicted in the simplified Figure 5.1 below.

Figure 5.1: Main relationships captured by model

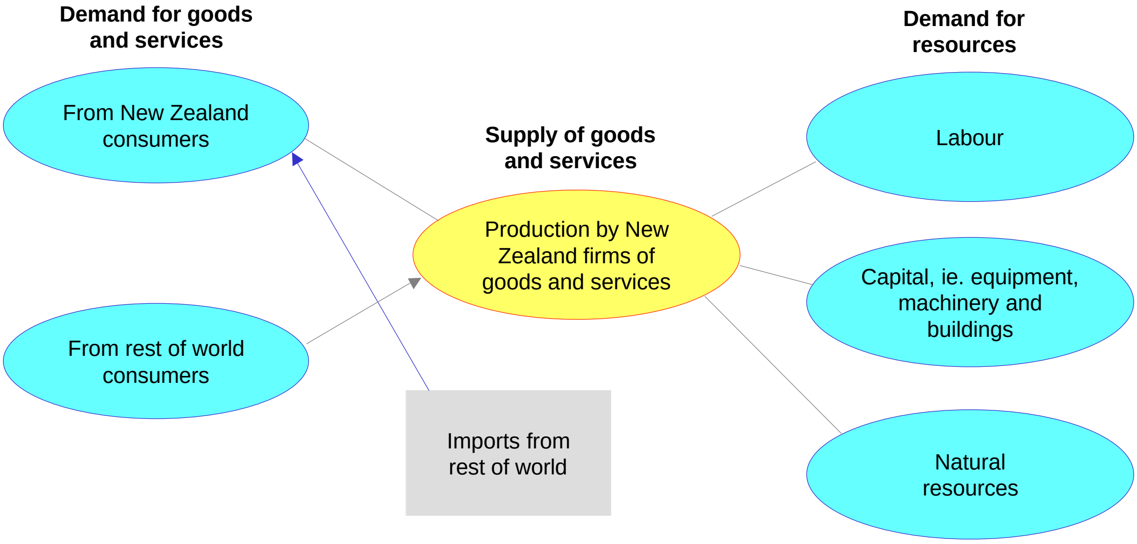


Figure 5.1 illustrates that the demands for New Zealand goods and services arise from two sources – namely from New Zealand consumers and consumers in the rest of the world – the latter being New Zealand's exports to the RoW.

On other side, the diagram indicates that to produce (and so supply) goods and services, New Zealand firms require a combination of labour, capital and natural resources. Not depicted, but captured through the modelling process, is the *technology* of New Zealand producers – namely the *way* in which they combine these three resources.

Another way that New Zealand consumers can obtain goods and services is through purchasing items made elsewhere (ie. imports from the RoW).

5.1.2 The balancing act

The 'balancing act' referred to is modelled through changes in the prices of goods, services and/or resources. The key assumptions behind this 'balancing act' are that:

- the price of goods will adjust to ensure that demand for those goods equals the supply of those goods, ie. if demand is greater than supply then the price of the goods in question will rise; if supply is greater than demand then its price will decline. A similar 'adjustment mechanism' is imposed for resources.
- New Zealand producers will endeavour to adjust their use of resources such that they make their products at 'least cost' – for example, if the price of capital rises, the New Zealand producer will attempt to use more labour and less capital (per unit of output).
- consumers (both New Zealand and foreign) will adjust their purchases towards those that are cheaper in comparison – for example, if the price of a New Zealand-made product becomes cheaper than that of its foreign-made equivalent, both New Zealand and foreign consumers will purchase more of the New Zealand-made product and less of the foreign-made item.

This 'balancing act' is performed at the individual industry, commodity and resource level – the model used separately identifies 49 industries (covering the whole of the New Zealand economy), 22 export commodities and 40 different types of labour.

It should be noted that the ability to adjust resource use is limited. This limitation is imposed through constraints mimicking the technological processes within each of the 49 industries.

Furthermore, the ability of consumers to adjust their purchases is also limited. In this context, the limitation incorporates the concept that consumer tastes and preferences are relevant, as well as price, when individuals make purchase choices.

Within this framework, 'laboratory-type' experiments are undertaken to investigate the implications of a particular change. An example follows.

5.1.3 An example

What would happen if there were a technological improvement that allowed all New Zealand producers to produce their goods using reduced amounts of both labour and capital per unit of output? A sequence of effects can be traced:

- In the first instance, there would be a reduced demand for both labour and capital that would lower their prices.
- This would enable New Zealand producers to produce goods at a lower cost than they had done so previously.
- As a consequence, New Zealand-made products are cheaper than before in comparison to their foreign-made competitors.
- As a consequence, both New Zealand and foreign consumers are more attracted to the New Zealand-made products and so demand more of these goods.
- New Zealand producers respond to this increased demand by attempting to produce more goods.

- In so doing, New Zealand producers demand more labour and capital resources to enable them to produce these additional goods.
- This demand for more resources will be met through increased employment where such resources are available – where they are not, the 'adjustment mechanism' will result in a rise in the price of such resources.
- This will then have further rounds of influences on production costs, prices, demands and supplies.

For convenience, the above is described as a sequential process. Within the modelling process however, the many first, second and further rounds of influences occur simultaneously.

The outcome from the model describes the overall impact of the change being investigated (in the above example, the technological improvement) after all the many rounds of influences have been completed and demands are equal to supplies (for all the individual commodities and resources incorporated in the model).

5.2 Inputs for the experiments investigating the release of GMOs

Consistent with argument outlined in the BERL (2000) review of the model simulations presented to the Royal Commission by Infometrics, as well as the above modelling framework, the results presented below explore the impact of three forces, namely:

- a reduction in the demand for particular New Zealand exports
- an improvement in the technology available to particular New Zealand industries
- an improvement in the technology available to foreign producers.

In isolation, each of these three forces *individually* will result in unambiguous impacts on the New Zealand economy, given the above modelling framework. Specifically:

- the case of a reduction in demand for some New Zealand exports, *on its own*, will unambiguously result in a negative impact on the overall New Zealand economy
- the case of an improvement in the technology available to some New Zealand industries, *on its own*, will unambiguously result in a positive impact on the overall New Zealand economy
- the case of an improvement in the technology available to foreign producers, *on its own*, will unambiguously result in a negative impact on the overall New Zealand economy.

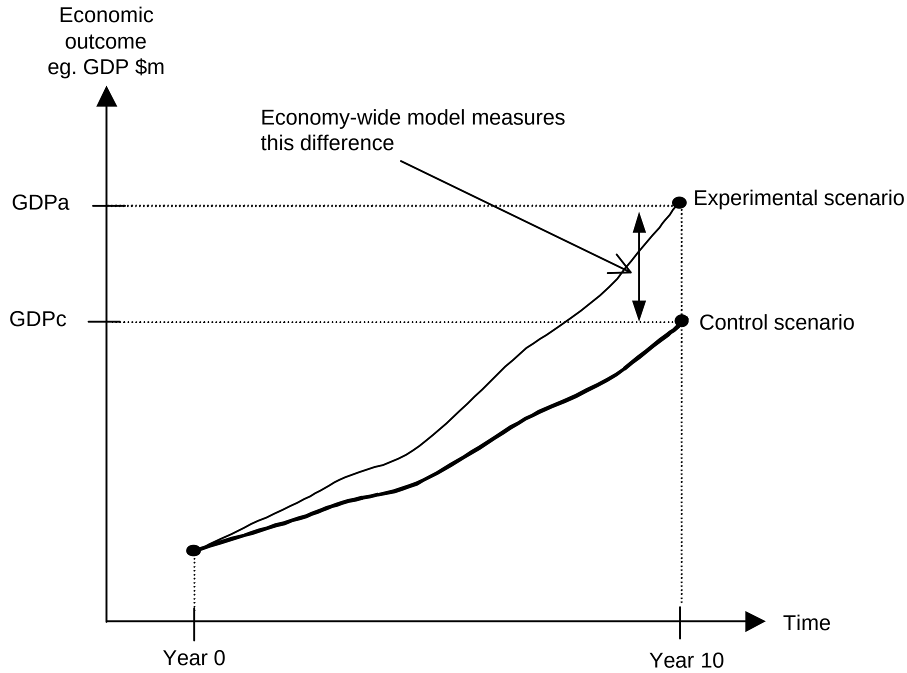
Note that in reality these three forces would not act in isolation. In these cases, the results of the model experiments provide information about the magnitude of the impact (given the size of the single original force) as well as details concerning inter-sector consequences.

In combination, however, the presence of 'opposing' forces means the overall impact on the New Zealand economy is ambiguous. In this case, therefore, the model provides information about the 'balance of these influences' and so determines whether the overall impact is positive or negative (again, given the magnitudes of the original forces imposed).

5.3 Interpreting the model

The results presented in the section below measure the effect of these 'opposing forces' after 10 years of their initial impact. The effects are expressed (usually in 'percentage change' terms) in comparison to the *control* scenario. This is illustrated in Figure 5.2 below.

Figure 5.2: Interpreting the economy-wide model experiment results

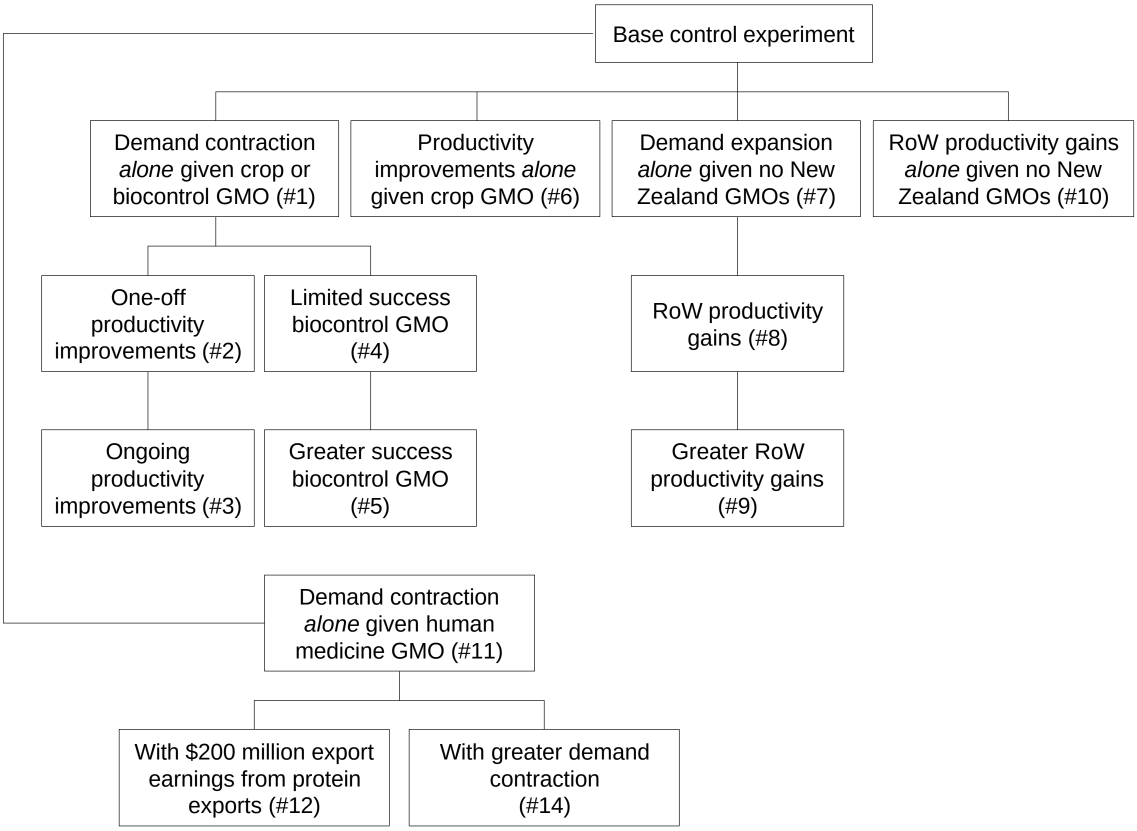


The model measures the difference between, for example, the level of GDP 10 years hence in the *control* scenario and the level of GDP 10 years hence in the experimental scenario. In particular, note that the percentage changes presented in the results tables are *not* differences in per annum growth rates. They are the percentage change in the *level* of GDP[8] 10 years from the initial impact.

The following subsections outline the results of numerous model experiments. The relationship between the experiments is illustrated in Figure 5.3 below. The associated reference numbers are also provided here.

[8] Or the percentage change in various other economic measures (eg. employment, exports, imports, consumption spending).

Figure 5.3: Schema of model experiments



5.4 The *control* or base case scenario

The fundamental of the modelling process depicted in Figure 5.2 above is the 'comparative' framework – ie. the outcome measured by the model experiments is the impact of the adoption (or otherwise) of a particular 'GMO scenario' compared to some '*control*' or base case scenario. Such a scenario is sometimes also referred to as a 'business-as-usual' picture of the economy.

Points to note concerning such a *control* scenario are:

- it is a model solution for the 'target horizon year' to serve as the basis for comparison (or a ground-reference) and represents a continuation of 'status quo'
- for the purposes of this project, the model's baseline picture is projected 10 years hence
- in the GM arena, such a baseline picture involves the adoption in New Zealand of technology and productivity as per historical trends (including, for example, marker-assisted selection); as well as importation and use of seeds consistent with testing and tolerance criteria as per the year 1998
- the *control* involves projections of export demand curve expansions (reflecting world demand growth), productivity growth and growth in capital resources, labour supply and employment, as well as growth in real government expenditure. Based on numerous general equilibrium model experiments undertaken over many years, the 'comparative' framework provides estimates of the impact of 'an experiment' or 'event' that are relatively insensitive to the outcome of the *control* scenario projections.

5.5 Schema of model experiments

The experiments presented in subsections 5.6 to 5.11 comprise:

- the *sole* impact of a demand contraction given the release of a crop or biocontrol GMO in New Zealand (this experiment is labelled #1)
- the *combined* impact of a demand contraction and a one-off productivity improvement through the release of a crop GMO (this experiment is labelled #2)
- the *combined* impact of demand contraction and ongoing productivity improvements through releases of crop GMOs (this experiment is labelled #3) – additional experiments investigating the effects of differing magnitudes of the imposed export demand contractions are explored in experiments labelled #3b and #3c
- the *sole* impact of a on-going productivity improvements through the release of crop GMOs (this experiment is labelled #6)
- the *combined* impact of demand contraction and productivity improvements through the limited success of the release of biocontrol GMO (this experiment is labelled #4) – additional experiments investigating the effects of differing magnitudes of the imposed export demand contractions are explored in experiments labelled #4a, #4b and #4c
- the *combined* impact of demand contraction and productivity improvements through the greater success of the release of biocontrol GMO (this experiment is labelled #5)
- the *sole* impact of a demand expansion as New Zealand refrains from using GMOs (this experiment is labelled #7)
- the *combined* impact of demand expansion and productivity improvements in the rest of the world through their use of GMOs (this experiment is labelled #8)
- the *combined* impact of demand expansion and greater productivity improvements in the rest of the world through their use of GMOs (this experiment is labelled #9)
- the *sole* impact of productivity improvements in the rest of the world through their use of GMOs (this experiment is labelled #10) – additional experiments investigating the effects of differing magnitudes of the imposed export demand expansions are explored in experiments labelled #10a and #10b
- the *sole* impact of a demand contraction given the release of a human medicine GMO in New Zealand (this experiment is labelled #11)
- the *combined* impact of a demand contraction and the effect of $200 million of additional receipts through protein exports from the release of a human medicine GMO (this experiment is labelled #12) – an additional experiment where the effect of $400 million of additional receipts through protein exports is undertaken in experiment labelled #13
- the *sole* impact of a larger demand contraction given the release of a human medicine GMO in New Zealand (this experiment is labelled #14) – an additional experiment with smaller imposed export demand expansions is explored in experiment labelled #14b.

Additional combinations of tests have been undertaken and are reported in the appendix document *Economy-wide model experiments.*

5.6 Pastoral GMO scenarios (refs #1 to #3 and #6)

Summary results of the set of experiments labelled ref #1 to ref #6 are listed in Table 5.1 below.

Table 5.1: Experiments with a crop GMO in New Zealand

% change from *control*	Lower export demand			= #3 but with a 50% *larger* export demand contraction	= #3 but with a 50% *smaller* export demand contraction	Ongoing productivity gain *alone*
	Alone	With one-off productivity gain	With ongoing productivity gain			
Identifier	**#1**	**#2**	**#3**	**#3b**	**#3c**	**#6**
Real GDP	-2.4	-1.2	-0.1	-1.3	1.2	2.5
Employment	-2.6	-1.5	-0.5	-1.9	0.8	2.2
Consumption	-1.4	-0.8	-0.3	-1.0	0.5	1.2
Export volumes						
Dairy	-7.8	-0.9	6.2	1.7	10.7	15.2
Meat	-8.8	-5.4	-2.0	-6.7	2.8	7.5
Horticulture	-23.2	-22.0	-20.9	-32.8	-8.9	3.0
Tourism	-5.7	-5.0	-4.3	-7.2	-1.4	1.5
Total (including others not shown here)	-3.8	-1.9	0.0	-2.0	2.0	4.1
Dairy and meat export receipts	-8.2	-4.1	0.0	-4.5	4.5	8.9

5.6.1 Lower demand for New Zealand-made products on world markets (ref #1)

The results of the first experiment illustrate the impact of a reduction in demand for New Zealand dairy, meat and horticultural exports as well as a reduction in tourism export demand. In line with the previous argument, the presence of this one force, *on its own*, means there is an unambiguous negative impact on the New Zealand economy.

The reduction in export demand imposed on the model (as described in the earlier section) were:

- reduction in demand for dairy exports = 7.8%
- reduction in demand for meat exports = 8.8%
- reduction in demand for horticulture exports = 23.2%
- reduction in demand for tourism exports = 5.7%

The effect of this lower demand for New Zealand exports results in 2.6% lower employment, with GDP lower by 3.4% in comparison to that in the *control* simulation.

The large proportion of this impact occurs in the agriculture sector, with flow-on impacts on the processing industries. There is also a noticeable impact on tourism-related transport sectors. Nevertheless, there are also repercussions across all other sectors as domestic household spending is lower as a result of the lower levels of employment.

As discussed earlier, however, the extent of this impact assumes the full translation of stated survey response to actual purchase behaviour. Where such a translation overstates the actual purchase response, then the overall economic impact would be consequently less than that reported in this experiment.

5.6.2 Reduced demand with one-off pastoral productivity gains (ref #2)

This experiment introduced a 'one-off' productivity improvement. This assumes that all pastoral agriculture output can be produced using 6.4% less labour and capital per-unit. This figure is also the equivalent of 2.5% pa higher productivity, across half of the pastoral agriculture output enjoyed for five years. Such a productivity improvement vis-à-vis the RoW enables New Zealand exporters to produce and sell their product at a more competitive price (again, compared to the *control* simulation).

The magnitude of this productivity improvement however, is insufficient to offset the impact of the lower demand. In other words, the 'balance of the two opposing forces' is dominated (in this instance) by the greater impact from the lower demand for New Zealand's exports. Nevertheless, the lower production costs arising from the productivity improvements do mitigate the demand-side impact.

Consequently, the results of experiment #2 give a 1.2% reduction in GDP when the demand contraction is accompanied by the 'one-off' productivity gain. This result compares with the 2.4% reduction in GDP arising from the lower export demand *alone*, as noted in experiment #1.

Employment is 1.5% lower in experiment #2 (compared to 2.6% lower in experiment #1), while total export volumes are 1.9% lower – with meat, horticulture and tourism exports bearing the brunt at, respectively, -5.4, -22.0 and -5.0% change on the level of exports in the *control* simulation 10 years hence.

5.6.3 Reduced demand and on-going pastoral productivity gains (ref #3)

The situation of greater productivity improvement (vis-à-vis the rest of the world) or, indeed, a sequence of ongoing productivity improvements, accompanying the lower export demand, is the next experiment. Here, productivity improvements of the order of 2.5% pa across 50% of pastoral agriculture enjoyed over 10 years is imposed.

This combination of forces results in a close to zero impact on overall New Zealand GDP, with GDP 0.1% below the *control* simulation. Employment is 0.5% lower than *control* with total export volumes unchanged.

5.6.4 Higher demand contraction and on-going pastoral productivity gains (ref #3b)

This experiment explores the sensitivity of the results to the imposed demand contractions. In particular, experiment #3b imposes the same productivity assumptions as were imposed in experiment #3 (namely, 2.5% pa over 50% of pastoral agriculture maintained for 10 years). In contrast though, experiment #3b imposes demand contractions that are 50% higher than those in experiment #3.

As a result of the larger impact from the export demand contraction, the overall outcome is more negative than the results tabulated for experiment #3. It is noticeable though, that the negative outcome is not as great as that in #1 (where there was no productivity gains but smaller demand contraction).

GDP is 1.3% below that of the *control*, with total export volumes 2.0% below *control*. Again, it is noticeable that horticulture and tourism exporters face the brunt of the demand contraction as they get little relief from the crop GMO-induced productivity improvements.

5.6.5 Smaller demand contraction and on-going pastoral productivity gains (ref #3c)

In this experiment the export demand contraction is reduced to half that imposed in experiment #3. The assumed productivity gains remain the same as those imposed in experiment #3.

With the effects of the demand contraction significantly lessened, the positive impacts from the imposed productivity gains have greater weight. As a result, overall GDP is 1.2% above that of the *control*, with labour employment 0.8% higher and total export volumes 2.0% higher. Consequently, the higher incomes flow through to consumption spending of 0.5% above the level in the *control* with imports also up 0.7%.

The combination of these export and import results show through in an improvement in the balance of trade to the tune of $300 million, compared to that in the *control* (not listed in table). Export receipts do not rise as much as export volumes – a reflection of the reduced prices necessary for such volume expansion. In turn, the ability of New Zealand exporters to improve their competitiveness with such lower prices is a direct result of the imposed productivity gains. Put alternatively, if productivity gains are not achieved, such price reductions cannot be offered and the consequential volume growth (in the face of the demand contraction) is not attainable. This is a reflection of the consistent and comprehensive nature of the general equilibrium solution.

It is important to note though, that these gains may well be difficult to achieve given that they incorporate significant increases (above those in the *control*) in dairy exports. Constraints on New Zealand's abilities to expand export volumes of this commodity (in the form of quotas, regulations and other effective barriers) could well limit the actual gains achieved here. Alternatively, in the face of such barriers, gains could be achieved through other avenues, such as additional (or relatively cheaper) resources being made available to other sectors.

Despite the smaller demand contraction, tourism exports however continue to record a decline in export volumes (1.4% below *control*).

5.6.6 Ongoing pastoral productivity gains only (ref #6)

On the other hand, the imposition of a productivity improvement, *on its own*, will have an unambiguous positive impact on New Zealand economic activity.

In such a case the impact amounts to an overall GDP of 2.5% above that of the control, with employment 2.2% higher. The positive gains are concentrated in the agriculture sector, reflecting the nature of the productivity improvements, although 'flow-on' effects across other industries are evident as a result of higher consumer spending on the back of higher than control employment levels.

Again, and carrying greater weight in regard to this experiment, a cautionary note needs to acknowledged. As above, these gains may well be difficult to achieve given that they incorporate significant increases (above those in the *control* simulation) in both dairy and meat exports. Constraints as described above could well limit the actual gains achieved here.

5.7 Pest control GMO scenarios (refs #4 and #5)

Where the productivity improvements imposed are a more focussed result of pest control operations – thereby impacting on the dairy, and sheep and beef farming sectors, their remains a similarity in the overall picture of impacts. That is, the 'balance of influences' is dominated by the reduced level of export demand imposed in the scenario.

Table 5.2: Experiments with a biocontrol GMO in New Zealand

% change from *control*	**Limited pest control gains with lower export demand**	**= #4 but with a 50% *greater* export demand contraction**	**= #4 but with *no* export demand reaction**	**= #4 but with a 50% *smaller* export demand contraction**	**= #4 but with *greater pest control gains***
Identifier	**#4**	**#4a**	**#4b**	**#4c**	**#5**
Real GDP	-1.3	-2.5	1.2	-0.1	-0.3
Employment	-1.6	-2.9	1.0	-0.3	-0.7
Consumption	-0.8	-1.6	0.6	-0.1	-0.4
Export volumes					
Dairy	-1.3	-5.5	7.1	2.9	5.0
Meat	-5.6	-10.1	3.6	-1.0	-2.5
Horticulture	-22.1	-33.9	1.5	-10.3	-21.1
Tourism	-5.0	-8.0	0.7	-2.2	-4.4
Total (including others not shown here)	-2.0	-4.0	1.9	0.0	-0.3
Dairy and meat export receipts	-4.4	-8.6	4.2	-0.1	-0.7

In particular, moderate success in controlling possum pests (resulting in a 6% improvement in productivity in these farming sectors) mitigates, to a degree, the impact of reduced export demand. As a result, overall GDP is 1.3% lower than the *Control* simulation (experiment #4). The successful control of possum pests (imposed by assuming a 12% improvement in these sectors' productivity – #5) is still insufficient to counter the negative demand influences facing New Zealand exporters – with GDP in this case 0.3% below the control experiment.

5.7.1 Pest control scenarios with differing demand contractions

Ref #4a

Experiment #4a imposes the same productivity assumptions as in the experiment #4, but assumes a larger demand reaction by imposing an export demand reaction 50% greater than that in #4.

This change has the effect of almost doubling the overall negative outcome as measured by GDP – down 2.5% below *control*, compared to 1.3% below *control* in experiment #4. This doubling in the negative outcome is similarly reflected in the results for employment, consumption and total export volumes.

The detail amongst the commodities shows the brunt of this demand reaction being faced by horticulture exporters, with significant reductions in dairy, meat and tourism exports also being recorded. In other words, the price competitiveness advantages arising from the productivity gains are clearly insufficient to outweigh the magnitude of the demand reaction imposed in this experiment.

Ref #4b

On the other hand, where there is no negative demand reaction the unambiguous positive impact of the imposed productivity gains are expected. This is the case with experiment #4b. The productivity gains assumed here are the same as for #4, but no demand contraction is imposed.

This results in overall GDP being a positive 1.2% above *control*, with employment up 1.0%, consumption 0.6% higher and total export volumes up 1.9%. Here, the full weight of the lower production costs through improved productivity is exhibited as dairy and meat exports, in particular, improve their price competitiveness and expand volumes. The second-round impacts (ie. through a lower economy-wide cost structure) also influences horticulture and, to a lesser degree, tourism exports as their export volumes and receipts record above-*control* outcomes.

Ref #4c

This experiment continues the investigation into the sensitivity of the results to the magnitude of the export demand contraction by retaining the same productivity gains as imposed for experiments #4, #4a and #4b, but imposes a demand contraction that is half that of the survey-based assumptions implemented in experiment #4.

This results in overall GDP almost unchanged from that of the *control* level – down 0.1%. Similarly, consumption and total exports are almost unchanged. In other words, the negative impacts from the imposed demand contraction in this experiment almost equally outweighs the positive impacts arising from the assumed biocontrol-GMO-induced productivity gains.

The impact on exports are relatively small across the dairy, meat and tourism commodities in comparison to the large negative impact on horticulture – again a reflection of the minimal benefits it directly receives from the imposed productivity gains.

5.8 Discussion of pastoral and pest control scenarios

Combining the information from these various sections, if New Zealand were to face a reduction in export demand for dairy, meat, horticulture and tourism commodities to the degree imposed in the above experiments, on-going productivity gains of 2.5% pa in 50% of pastoral agriculture over 10 years would be required to mitigate its impacts.

In the case where the export demand response is less than has been imposed in these experiments, the more the overall outcome will be influenced by the impacts from the productivity improvements. For example, if the export demand reduction was one-half of the level derived from the survey, then the ongoing productivity gain modelled would be sufficient to result in GDP of 1.2% above the *control* scenario.

As discussed earlier though, it is the very magnitude of either of these 'original impacts' that remains the subject of considerable uncertainty. The export demand shifts of the magnitudes implied through the survey results are considerable. The model experiments confirm that their impacts are also considerable. Similarly, the imposed productivity improvements are also of a significant magnitude.

These results confirm that reducing the uncertainty to establish actual (as opposed to surveyed) purchase response to GMO release is pivotal to determining its impact on the New Zealand economy. Similarly, greater information aimed at confirming the actual (as opposed to asserted) productivity gains from GMO release is the other critical element that is a pre-requisite for an conclusive determination of the economic impact.

5.9 Scenarios where New Zealand foregoes GMOs (refs #7 to #10)

The situation where New Zealand foregoes GMOs is mimicked by the modelling framework again through a balance of two influences:

- an increase in the demand for particular New Zealand exports
- an improvement in the technology available to producers elsewhere in comparison to that available to particular New Zealand industries.

5.9.1 Demand expansion alone (ref #7)

The results of the first experiment here illustrates the impact of an in demand for New Zealand dairy, meat, horticultural and tourism exports. Consistent with earlier arguments, the presence of this one force, *on its own*, means there is an unambiguous positive impact on the New Zealand economy.

Table 5.3: Experiments with no GMOs in New Zealand

% change from *control*	Higher export demand: Alone	With *moderate* productivity gain in RoW	With *greater* productivity gain in RoW	With RoW productivity gain *alone*	= #10 with 50% *smaller* export demand expansion	= #10 with 50% *larger* export demand expansion
Identifier	**#7**	**#8**	**#9**	**#10**	**#10a**	**#10b**
Real GDP	7.5	3.4	-0.1	-6.4	-3.2	3.2
Employment	8.0	3.9	0.2	-6.5	-3.1	3.7
Consumption	4.3	2.0	0.0	-3.6	-1.8	1.9
Export volumes						
Dairy	13.8	-12.7	-35.5	-43.3	-39.3	-31.5
Meat	15.5	-11.4	-34.5	-43.3	-38.9	-30.1
Horticulture	34.4	3.1	-23.9	-43.3	-33.5	-14.0
Tourism	34.4	34.3	34.0	-0.1	17.2	51.5
Total (including others not shown here)	12.2	5.9	0.4	-9.9	-4.7	5.7

As outlined in the earlier section, the increase in export demand imposed on the model consisted of:

- an increase in the demand for dairy exports of 13.7%
- an increase in the demand for meat exports of 15.4%
- an increase in the demand for horticulture exports of 34.3%
- an increase in the demand for tourism exports of 34.3%.

Such a favourable export demand change results in gains to the New Zealand economy in terms of 7.5% higher GDP, 8% higher employment and 12.2% higher export volumes in total (all compared to their respective levels in the *control* simulation).

However, the comment made earlier with respect to simulation ref #6 applies here as well. In particular, the unambiguous positive impact on the New Zealand economy relies on significant and substantial increases in dairy and meat export volumes being sold (over and above those attained in the *control* simulation). Repeating the comment made earlier, constraints on New Zealand's abilities to expand export volumes of these commodities (in the form of quotas, regulations and other effective barriers) could well limit the actual gains achieved here.

5.9.2 Demand expansion with RoW productivity gains

Introducing to the model some productivity improvements in the Rest of the World results in potentially significant and substantial consequences for New Zealand dairy and meat export volumes. The primary cause behind this impact is the responsiveness (or sensitivity) of a large proportion of foreign consumers to price differentials.

In other words, as described earlier from the survey results, while a proportion of foreign consumers expressed a clear preference for conventionally produced goods and services, there exists a larger proportion of foreign consumers that are prepared to change their purchasing behaviour on the basis of price.

Ref #8

One model experiment imposes an improvement in productivity in the rest of the world to the extent that the price competitiveness of New Zealand dairy, meat and horticultural products deteriorates by 6.4% in total over a 10-year horizon. This is imposed in tandem with the increase in demand for particular New Zealand exports described in the previous paragraphs.

The balance of these two influences (ie. the increase in demand for New Zealand exports from some foreign consumers, and the loss of price competitiveness of New Zealand exports) continues to result in overall gains to the New Zealand economy. GDP is 3.4% higher than in the *control* simulation, with employment 3.9% higher.

The benefits here arise, in the main, from the expansion in tourism exports (which are not exposed to the reduction in price competitiveness imposed on New Zealand's commodity exports). As a consequence, tourism related transport and accommodation industries expand considerably (above the *control* simulation), with the higher employment flowing on to higher consumer expenditure which impacts across the range of domestic industries.

Ref #9

Another model experiment imposes greater productivity gains in the Rest of the World. In this case, a deterioration in the price competitiveness of New Zealand dairy, meat and horticultural products of 13.2% is imposed.

In this case the balance of these two influences results in no change to overall GDP (a marginal -0.1% compared to the *control* simulation) with employment 0.2% higher.

Noticeably though, the expansionary shift in demand in this case, is now insufficient to counter the loss in price competitiveness in dairy, meat and horticulture products. As such, despite the expansion in export demand (originating from those expressing a preference for conventionally-produced goods), export volumes of these products suffer as they bear the brunt of the competitiveness loss.

5.9.3 Foregoing GMOs but with differing demand expansions

Ref #10

On the other hand, the imposition of a productivity improvement in the RoW, *on its own* with no favourable demand expansion assumed, will have an unambiguous negative impact on New Zealand economic activity.

Where New Zealand foregoes the use of GMOs, productivity improves in the RoW and there is no positive demand movement, there are unambiguous losses to the New Zealand economy. The brunt of these losses is borne by dairy, meat and horticulture exports, and in this instance there is no counter expansion in other exports to compensate for these losses.

Ref #10a

This experiment continues the imposition of a relative productivity gain by New Zealand's competitors of the order of 13.2%, but assumes a favourable export demand shift of half that implied by the survey responses (ie. half those imposed in experiment #9).

The results here see the impact of the loss in price competitiveness dominate the effects arising from the favourable demand shifts. In particular, GDP is 3.2% below *control*, with consumption down 1.8%, employment down 3.1% and exports 4.7% lower.

It is noticeable that the expansion in tourism export volumes (and revenues) is insufficient to outweigh the significant reductions (compared to *control*) in dairy, meat and horticulture commodities. Despite the fall in imports as a consequence of the overall lower level of activity, the impact on exports dominates such that the overall balance of trade also deteriorates (compared to *control*).

Ref #10b

In contrast, this experiment imposes the same productivity gains for the rest of the world as in #10, but assumes a favourable demand shift of 50% above those implied by the survey responses (ie. 50% above those imposed in #9).

In such a case, the significant expansion in tourism exports (as it takes full advantage of the favourable demand shift) is more than sufficient to outweigh the negative impacts from the loss in price competitiveness. Consequently, GDP is 3.2% above *control*, with employment higher by 3.7%, total export volumes up 5.7% and consumption up 1.9%.

It is noticeable, though, that despite the favourable demand shifts also applying to New Zealand dairy, meat and horticulture exports, the price competitiveness losses here are sufficient to more than dominate the outcome for these commodities.

5.10 Human medicine GMO scenarios (refs #11 to #14)

The situation where New Zealand exporters face a negative demand reaction resulting from New Zealand's release of a human-medicine GMO, clearly imposes losses on the New Zealand economy. The export losses are tilted against those facing the largest demand contraction (ie. horticulture, followed by dairy and meat, with tourism exports suffering the least).

Table 5.4: Experiments with a human medicine GMO in New Zealand

% change from *control* situation	Lower export demand			*Larger* reduction in export demand *alone*	*Smaller* reduction in export demand *alone*
	Alone	With +$200 million protein exports	With +$400 million protein exports		
Identifier	**#11**	**#12**	**#13**	**#14**	**#14b**
Real GDP	-0.9	0.4	1.4	-1.4	0.5
Employment	-0.9	0.1	0.8	-1.3	-0.5
Consumption	-1.3	0.2	1.5	-2.0	-0.7
Export volumes					
Dairy	-2.8	-1.9	-1.3	-4.3	-1.5
Meat	-3.3	-2.4	-1.8	-5.0	-1.7
Horticulture	-10.9	-10.2	-9.6	-16.0	-5.3
Tourism	-1.7	-0.8	-0.1	-2.6	-0.9
Total (including others)	-0.9	0.2	1.1	-1.4	-0.5

Ref #11

The role of the #11 scenario is conceptually analogous to that of the first #1 scenario. That is, it provides a picture of the economy on the assumption that the development of a GMO-based human therapeutic (proteins for enzyme replacement therapy – see subsection 4.4) has a negative effect on the demand for New Zealand's exports, without at this stage considering any of the benefits that the GMO-based development may bring. The fall in economic activity is not quite as severe, simply because the reduction in export is demand is assumed to be less severe than with a GMO-based development related to food production.

Ref #12 and #13

Scenario #12 incorporates into #11 the effect of $200 million worth of exports of GMO-derived proteins, plus ongoing research and development expenditure of $5 million per annum. These changes are more than the fall in GDP observed in #11.

Where the human-medicine GMO is New Zealand-produced and additional export revenues are gained from such a product, the negative demand influences are mitigated to a degree by such export revenues. Net gains to the overall economy are exhibited in the form of additional GDP, employment and consumption. Export volumes of dairy, meat and horticulture still decline however, (but by less than in #11) as they continue to face the brunt of the demand contraction.

The overall message is that if the development of a GM-based human therapeutic leads foreign consumers to turn away from New Zealand products to the extent assumed in #11, then $200 million of additional exports in the form of GM-derived proteins is sufficient to offset the initial negative economic effects of the decline in traditional exports.

From the discussion in subsection 4.4, the $200 million of protein exports could well be a conservative estimate. In scenario #13 it is assumed $400 million of such exports are enjoyed. This assumption is sufficient to lift GDP by nearly 1.4% above the *control* simulation. Employment, private consumption and even exports are also above their *control* levels. Exports of dairy, meat, and horticulture are however still well down on *Control* levels, but over the 10-year horizon the difference in their rates of growth is less than 1% per annum.

Ref #14

Experiment ref #14 imposes a greater negative export demand reduction. This is close to the first #1 scenario in a quantitative sense because the negative shifts in export demand are similar, albeit still not quite as severe. Not surprisingly the fall in GDP is more than in #11, but less than in #1. However, private consumption absorbs relatively more of the fall in export demand in this experiment (ie. #14) than in #1, with the net exports (exports less imports) absorbing correspondingly less in #14. This occurs because of a small change between these runs in the way the government sector is modelled. In the human medicine scenarios the potential worsening of the fiscal balance caused by the lower level of economic activity, is prevented by an increase in personal income tax rates. This causes a larger fall in private consumption than in the crop and biocontrol GMO scenarios.

The results for GDP and employment imply that these variables are not sensitive to this difference in modelling assumptions.

Ref #14b

A further experiment testing the sensitivity of the results to the magnitude of the demand contractions is undertaken in that labelled #14b. The demand contraction imposed here is equivalent to half of that imposed in #11. Again, with only the negative influences from the imposed export demand contraction present in this experiment, an overall negative impact on GDP, employment, consumption, and total exports is expected. The listed results indicate the magnitude of this negative impact lies roughly mid-way between no change on *control* and the outcome for experiment #11.

5.11 Discussion of human medicine scenarios

In conclusion, if the development of GMO-based proteins for human medicine in New Zealand leads to the sort of reduction in demand for New Zealand exports that might occur under the #1 scenario, then protein exports of around $200 million–$500 million would be required to offset those changes in consumer demand. Again, if there is almost no adverse change in consumer sentiment, then any level of protein exports are positive for the economy.

Looked at somewhat differently, if a GMO development along the lines of a #1 scenario (ie. a crop or biocontrol GMO-based productivity improvement) were to occur first, then it is unlikely that there would be any further shift by foreign consumers away from New Zealand products if GMO-based proteins for human therapeutics were also to be developed here. In this there would be very little downside from exports of GMO-based proteins.

Such a ‘combined’ simulation has been undertaken. This scenario combines the assumed productivity improvements from the release of a crop GMO along with the demand contractions as per experiment #3 with an assumed $200 million in protein exports as per experiment #12. This results in GDP just over 1% higher than the *control* scenario 10 years hence, with consumption 1.2% higher and employment 0.3% higher.

The reverse sequence might also present an interesting scenario. That is, if a GMO-based human medicine is the first GMO development in New Zealand, and this has only a small effect on the demand for New Zealand goods in overseas markets, then demonstrable success in this regard (no adverse health or environmental consequences), might make some overseas consumers less reluctant to buy other New Zealand exports if crop or biocontrol type GMO scenarios were to follow later.

5.12 A combined scenario

Table 5.5 below lists the results from a ‘combined’ scenario. This experiment (#15) assumes:

- an export demand contraction (below *control*) against New Zealand exports of dairy, meat, horticulture and tourism consistent with the survey responses on the release of a crop GMO in New Zealand – in other words, the demand contraction is the same as that imposed in experiment #1
- crop-GMO-induced productivity gains across half of New Zealand pastoral agriculture of 2.5% pa (above *control*) maintained for 10 years – in other words, the productivity assumptions imposed are the same as those imposed in experiment #6
- the release of a human medicine GMO in New Zealand with the effect of $200 million worth of export revenue (above *control*) from GMO-derived proteins – in other words the protein exports assumptions are the same as those imposed in experiment #12.

The results of experiment #15 indicate that while the balance between the impacts of the first two influences (ie. between #1 and #6) is evenly-poised, the addition of $200 million of export revenue from GMO-derived proteins provides an overall positive outcome for GDP, employment, consumption and total export volumes (compared to *control*).

It should be clearly noted that this experiment assumes that while the release of a crop GMO results in a negative export demand contraction, there are no further demand contractions from the release of a human medicine GMO.

The outcome of these imposed productivity gains, export demand contractions and additional protein export receipts is a gain to overall GDP to the tune of 1.1% above *control*. Employment is 0.3% higher – a reflection of the commodity composition and nature of the input assumptions. However, the gains from the additional protein export revenues are seen in through the rise in consumption (up 1.2% compared to *control*).

It is noticeable, though, that the brunt of the demand contraction continues to be felt by horticulture exports – where the mitigating influences of productivity gains appear only marginally present.

Table 5.5: Results from the release of a crop GMO and a human medicine GMO

Label	#15
% change from *control* level	
Real GDP	1.1
Labour employment	0.3
Capital stock employed	0.9
Real consumption	1.2
Real export volumes	1.0
Import volumes	0.4
Trade balance (absolute $ million change from control level)	-178
GDP deflator	-1.0
Terms of trade (NZ $)	-1.1
Terms of trade (world $)*	0.0
Export volumes	
Dairy exports	7.0
Meat exports	-1.2
Horticulture	-20.3
Tourism exports	-3.5
Export receipts	
Dairy exports	3.1
Meat exports	-3.1
Dairy and meat subtotal	0.6
Horticulture exports	-21.1
Tourism exports	-4.0

* Imposed, ie. *not* model determined.

6 Agricultural Trade Model Experiments

This section of the report describes the results obtained from GEMO, a model of international agricultural trade. This model simulates trade amongst New Zealand, the United States, the European Union, and several other countries for all the main New Zealand commodities. Because it includes other countries, the model can analyse how changes overseas such as technological changes affect New Zealand agriculture, in particular regarding producer, consumer and trade prices both in New Zealand and overseas. In addition, as an integrated multi-commodity model, GEMO can assess the impacts on all agricultural sectors simultaneously. For example, it is possible to examine the impact of a new dairy technology in the US on beef production in New Zealand. This feature of the model is important, given the multiple alternative uses for agricultural inputs.

Agricultural production is divided into GM and non-GM sectors for all countries and commodities. This separation allows the model to analyse the effect of a demand preference for one type of product on other agricultural commodities. This demand preference can be specified for a particular country or region, such as the EU, or for all world consumers. The separation of GM and non-GM production also allows productivity impacts from GM technology to be applied only to those countries and commodities that adopt GM technology. Furthermore, the productivity effect can be specified by country and crop, allowing GEMO to model a situation in which New Zealand improves its productivity faster than other countries do.

6.1 The empirical model

The empirical model, GEMO, has been used in prior research and is a product of Lincoln University's LTEM (Lincoln Trade and Environment Model). More detail on the model is presented in the appendix document *LTEM model details* and further detail behind the model can be found in Cagatay and Saunders (2003). GEMO is a model of international agricultural trade, and is used to analyse prices, demand, supply, and net trade levels (Saunders et al 2000). The model has been developed from earlier model used in Uruguay round of trade negotiations and was originally developed in the USDA. Thus the model incorporates information from a number of studies of trade dynamics, agricultural production, government support policies, and more, from various researchers and policy analysts around the world. Because of its empirical grounding, the model incorporates a range of policies affecting world markets. It does not however, investigate the economy-wide impacts of policy changes or events.

The model simulates the effect of market and policy changes on the domestic quantities and prices in each country and from this calculates the new equilibrium world market price. This is the world price that equilibrates total demand and supply of each commodity in the world market. GEMO can capture disequilibrium situations in the economy that may result from temporary shortages or excess supply situations by allowing the determination of stock levels endogenously. The advantage of this approach is that changes to price and quantity are modelled together.

GEMO models international trade for eight separate countries, including the European Union as one country, and the rest of the world together. Trade is modelled for 16 commodities, including those commodities most important for New Zealand's production and trade. Each commodity has both GM and non-GM products. Model parameters are estimated using data from the year 1997, and simulations are carried out for years up to 2010. The countries and commodities are given in more detail in the appendix document *LTEM model details*.

6.2 Results

This section presents the results obtained from GEMO. For each scenario, the model parameters in question are changed incrementally over the course of 10 years. The model is then simulated for 10 years, solving each year. The results below are the model solutions for year 10 (2010). They are snapshots of New Zealand's position 10 years hence, that is, they are not a cumulative sum of all 10 years.

Results are presented as changes from the base model, summarised into total producer returns and producer returns from exports, as outlined in the project brief. Clearly the trade model provides information on many more variables than this including trade, producer and consumer prices; volumes of production and trade as well as selected input use, for all countries and commodities separately.

However, the summary of results into producer returns does focus on the main impact to New Zealand from scenarios relating the different alternative strategies and market scenarios. The scenarios described below were chosen to reflect results from the surveys reported elsewhere in this report, the literature review, and input from the steering committee. Where these sources were insufficient, further assumptions were necessary for modelling purposes. In general, these assumptions were made with an eye to transparency and consideration of the full range of possible impacts. While in theory an infinite number of different combinations of productivity and demand shifts can be modelled, available resources constrained the number of simulations we could run.

6.2.1 Base model

In the base or *status quo* model, New Zealand does not adopt GM technology for production agriculture. For modelling purposes, the actual percentage of GM crops is 0.1% of New Zealand production. This small amount is required for the model to converge on a solution. The rest of the world has divided its agricultural production and consumption into GM and non-GM sectors, each of which accounts for 50%.

There are no productivity effects or demand effects from the use of GM in the base model.

6.3 Scenario: New Zealand releases pastoral GMO

In this scenario, the New Zealand pastoral sector adopts GM ryegrass for 50% of its production. We assume that this is reflected in an increase in the productivity of dairy, beef, and sheep sectors. As no definite estimate of productivity was available, four resulting alternative productivity effects were considered:

- no effect
- 25% productivity increase
- 40% productivity increase
- 60% productivity increase.

These productivity increases are assumed to occur over a period of 10 years.

The NRB and Lincoln surveys provided insight into consumer perceptions. Unfortunately, they and other surveys have not yielded an exact demand shift. We therefore modelled a simple demand shift that approximates the effects suggested in the NRB survey and is also suggested in research by Burton et al (2001). The two possible demand effects used in the modelling were:

- no effect
- 20% discount on all New Zealand meat, dairy products, and fruit.

Finally, three different adoption timelines were considered:

- New Zealand is the only country to increase its productivity for all 10 years modelled
- New Zealand increases its productivity for five years, then other countries begin increasing theirs
- all countries increase their productivity similarly for all 10 years modelled.

The basic results using the first adoption timeline are presented in the following table. The percentages shown indicate the changes from the base model to the alternative modelled, calculated as a change in total producer returns in the agricultural sector. Empty cells in the table indicate that the particular combination was not modelled.

Table 6.1: Change in producer returns from GM ryegrass adoption: New Zealand only adopts

Demand effect	Productivity effect			
	None	25% increase	40% increase	60% increase
None	0.8%	5.1%	8.1%	10.5%
20% discount for all New Zealand meat, dairy, and fruit	-43.3%	–	–	–

The results indicate that without a demand effect, a productivity increase in GM pastoral agriculture would lead to an overall gain to agriculture proportional to the size of the productivity increase. If adoption of GM technology leads to across-the-board discounts on New Zealand meat, dairy products, and fruit, then the demand shift leads to a loss in producer returns. In the case where there is no productivity improvement, this discount leads to a reduction in producer returns of 43.3%.

As would be expected from economic theory, as outlined in more detail later, the inward shift of the demand curve results in both lower quantities produced and lower prices for New Zealand products. Because GEMO is a model of international trade, it models both the price and quantity shifts simultaneously, thus giving a picture of the full impact of a discount on New Zealand products from our overseas markets. This capability of the model is particularly important for New Zealand's main exports. For example, New Zealand produces a small portion of total world dairy products, but accounts for 23% of world milk powder exports, 36% of world butter exports, and 19% of world cheese exports (1997 figures). An increase in the quantity of New Zealand exports will therefore decrease their world prices, and because New Zealand is an open economy, lower world prices result in lower farmgate prices.

The economy-wide model scenario labelled #6 in the previous section (2.5% per annum productivity improvement and no demand shift) used similar assumptions to the modelling presented in the table above that included no demand effect and a 25% increase in productivity.

The NRB survey results indicated that all New Zealand products would be affected by a discount because of the adoption of GM technology in commercial agriculture. However, we did examine the possibility that only those products grown using GM may be subject to a discount, and that non-GM products were exempt. This also reflects a scenario that not all products from New Zealand would be affected or tainted by the loss of our clean green image. The result of modelling this segregated products scenario alongside a 25% increase in productivity is presented below.

Table 6.2: Change in producer returns from a 25% productivity increase and segregated products

	Productivity effect
Demand effect	25% increase
20% GM discount on GM products only	-5.5%

This result demonstrates the importance of the assumption as to whether a discount applies to all New Zealand products or just those produced using GM technology. If New Zealand were able to sell products in both GM and non-GM markets, the effect of a demand shift against GM products would be softened. Note that the assumptions behind the economy-wide model results described in section 5 above are consistent with the survey questionnaire and responses – ie. the price discounts apply to all New Zealand dairy, meat and fruit products and holidays, irrespective of their individual GM or non-GM status.

The preceding results were obtained from modelling in which New Zealand alone had access to GM technology that enhanced its livestock productivity. To test the importance of this assumption, two additional alternatives were examined. In the first, New Zealand started increasing its livestock productivity in year 1. Other countries then began to have access to the technology five years later. In the second alternative, all countries were assumed to have access to the technology in year 1 and thus began increasing productivity at the same time and increased it at the same rate.

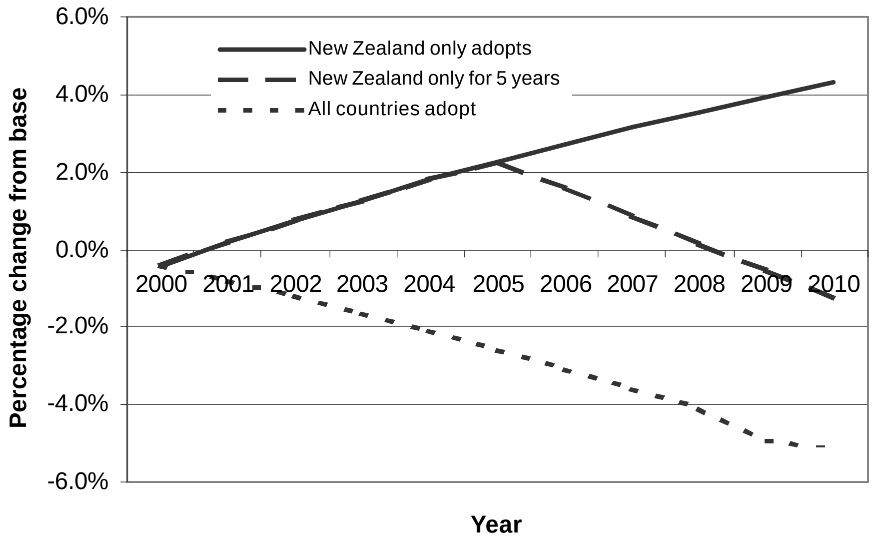
Table 6.3: Change in producer returns from a 25% productivity increase

Demand effect	Uptake alternatives		
	New Zealand only adopts	New Zealand only for 5 years	All countries adopt
None	5.1%	-1.3%	-5.2%

This table illustrates that if the technology was available in the rest of the world in year 10, New Zealand producer returns fell. When other countries adopted the technology five years after New Zealand did, producer returns fell by 1.3%; when other countries adopted it at the same time and rate as New Zealand, returns fell by 5.2%. In these scenarios, it was assumed that ryegrass adoption had the same effect on livestock productivity in other countries as it had in New Zealand.

For these scenarios, a time series is shown in the figure below. As New Zealand alone increased the productivity of its livestock sector, its returns grew. As other countries adopted productivity-enhancing GM technology, New Zealand returns shrank. The graph below clearly shows this relationship.

Figure 6.1: Percentage change in producer returns from GM ryegrass in New Zealand



Changes to export returns are also important for New Zealand. These followed much the same pattern as producer returns. The different combinations of productivity changes and demand preferences led to the following changes in export returns.

Table 6.4: Change in export returns from GM ryegrass adoption: New Zealand only adopts

Demand effect	Productivity effect		
	None	25% increase	40% increase
None	0.0%	2.4%	5.6%
20% discount for all New Zealand meat, dairy, and fruit	-41.7%	–	–

Increasing pastoral productivity had a positive effect on export earnings. However, a 20% discount for New Zealand products resulted in a large decline in returns from exports.

Export returns were obtained for the different adoption timelines. These are presented below.

Table 6.5: Change in export returns from a 25% productivity increase

Demand effect	Uptake alternatives		
	New Zealand only adopts	New Zealand only for 5 years	All countries adopt
None	2.4%	-8.6%	-16.3%

New Zealand export returns increased somewhat when it alone used GM to increase livestock productivity. However, when other countries follow suit, New Zealand export returns fell.

This modelling addressed a number of possibilities from the adoption in New Zealand of GM ryegrass. Producer returns and returns from exports increased as productivity gains were obtained. However, these higher returns were eroded when other countries began adopting similarly productive GM technology. Further gains were obtained from higher prices for non-GM products.

6.3.1 Scenario: GM possum control

This scenario has not been modelled separately because it would be modelled exactly the same way as the GM ryegrass scenario: a productivity increase in pastoral agriculture in New Zealand. The same conclusions apply.

6.4 Scenario: New Zealand foregoes use of GMOs

In this scenario, New Zealand does not adopt GM technology in agriculture. Formally, this situation was modelled by reducing the GM sector in New Zealand to 0.1%, as in the base model. This small percentage was required to allow the model to solve but does not materially affect the results.

By contrast, it was assumed that the rest of the world adopted GM technology for 50% of its agricultural production. Productivity gains were applied across all products, that is, for those that have current commercial products (oilseeds, maize) and for those do not (kiwifruit, apples, coarse grains).

Several different productivity changes were examined:

- no change
- 10% increase
- 25% increase
- 60% increase.

Different possibilities on the demand side were also modelled:

- no price differential
- 20% non-GM premium
- 50% non-GM premium.

The different productivity and demand possibilities created 12 possible scenarios, not all of which were required by the brief. The following table presents the results obtained from the alternatives modelled.

It should be noted that it is not possible to directly compare the results below with those from the economy-wide model. GEMO dynamically calculates world prices based on quantities produced, which are in turn a function of technology and productivity. Given a productivity change, the LTEM is able to estimate the impact of greater supply in our overseas markets on trade volumes and prices, which in affect New Zealand prices and production. This is an important difference between the two models: GEMO inputs a productivity change, then simulates the resulting price and quantity changes. The economy-wide model assumes a horizontal shift in the demand curve and inputs that directly into its model.

Table 6.6: Change in producer returns from New Zealand non-GM[9]

Demand effect	Productivity effect			
	None	10% increase	25% increase	60% increase
None	0%	0%	0%	-8.2%
20% non-GM preference	–	–	33.0%	13.2%
50% non-GM preference	108.9%	125.2%	118.3%	–

This table shows that when no preference existed for non-GM products, an increase in productivity for GM crops did not affect New Zealand unless the increase rose to 60%. This may be somewhat surprising at first. However, the markets into which New Zealand exports are highly regulated, so their domestic productivity increases do not affect New Zealand exports at lower productivity levels. If there was a 20% preference for non-GM products, then even with increased productivity overseas of 25% or 60%, New Zealand returns rose by 33.0% and 13.2% respectively. The greatest increase in New Zealand returns occurred, however, with a 50% preference for non-GM products. In that case, returns rose by 108.9% to 125.2%, depending on overseas productivity.

The export returns that New Zealand producers earned in this scenario followed a similar pattern to the overall producer returns, as shown in the table below.

9 Caution should be used in interpreting the results when a 50% preference for non-GM products or a 60% productivity increase is simulated. As noted above, the model is calibrated to simulate marginal changes.

Table 6.7: Change in export returns from New Zealand non-GM

Demand effect	Productivity effect			
	None	10% increase	25% increase	60% increase
None	0%	0%	-0.1%	-6.3%
20% non-GM preference	–	–	34.6%	16.6%
50% non-GM preference	104.3%	113.6%	114.2%	–

As above, New Zealand producers had large gains from non-GM product preferences. Returns were reduced by large productivity increases in the GM sector.

6.5 Discussion of GM scenarios on agriculture

When New Zealand alone could increase its agricultural productivity, producer returns increased. The size of the increases reflected the tension between rising export volumes and declining trade prices. However, in those alternatives in which all countries increases production, New Zealand lost revenues as it competed with larger countries.

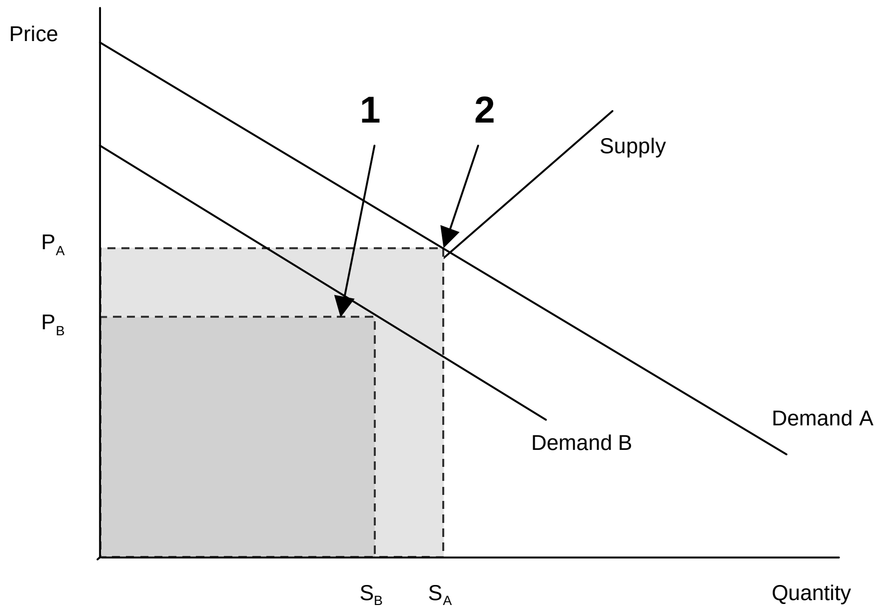
Producer returns were more responsive to demand changes. Discounts on New Zealand products resulting from adoption of GM technology clearly reduced New Zealand producer returns. Any premium that New Zealand could capture from foregoing GM release, preserving and expanding on its CGI, clearly resulted in gains to New Zealand producers.

The modelling results also address the robustness of two different strategies – adoption or non-adoption of GM pastoral technology. New Zealand stands to gain from adopting GM technology if other countries do not increase their productivity and if consumers do not discount GM products too much. Other the other hand, by foregoing GM technology, New Zealand is buffered from commodity price drops for a range of GM productivity increases, and stands to gain from any preference consumers may have for non-GM products.

This overall result is a direct consequence of the interaction of supply and demand and of New Zealand's size and position in international trade. A supply-side strategy focusing on raising New Zealand's productivity would be less effective at increasing producer returns than would be a demand-side strategy raising demand for New Zealand products.

The results of the modelling are consistent with both experience and theory. The results show clearly the different impacts of supply and demand shifts on producer returns to New Zealand. This is illustrated below by the two figures below. Figure 6.2 shows a demand shift for a product with the demand curve moving from Demand A to demand B, the case of a discount on New Zealand products. A movement from Demand B to Demand A would be a premium for New Zealand products. What is clear from Figure A is that the demand shift has an unequivocal effect on producer returns. If we assume a decrease in demand then producer returns decrease from the larger area 2 to the smaller area 1. Whilst the size of this impact will be influenced by the relative elasticities of supply and demand, there will always be a decrease in producer returns.

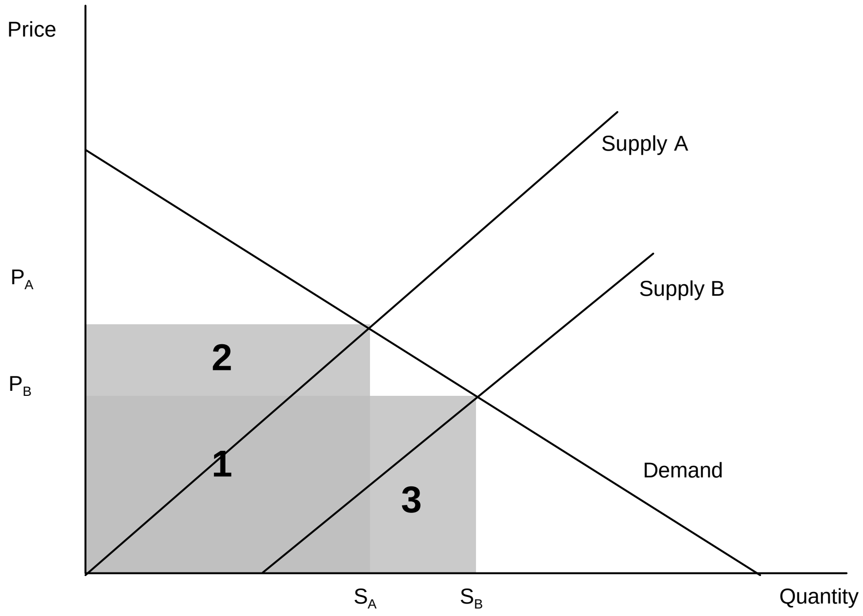
Figure 6.2: Impact on producer returns from reduction in demand



In the case of shift in supply the result is not as certain. This is illustrated by Figure 6.3. This illustrates a shift in supply, representing an increase in productivity, from Supply A to Supply B. Producer returns change therefore from the areas in boxes 1 and 2 to the areas in boxes 1 and 3. Thus whether there is an overall gain in producer revenue or not depends upon whether the loss of area 2 is less than the gain in area 3. This is dependent on the relative elasticities of supply and demand. If demand is considered more responsive than supply the n producer returns will increase. However if demand is less responsive than supply then producer returns will actually fall. The evidence from agricultural markets is that the latter holds true and an increase in supply does lead to a fall in producer returns. This is seen in the case of the adoption of rbST, which has a significant increase in productivity but no effect on profits (Foltz and Chang, 2002).

These diagrams indicate that the modelling results are consistent with economic theory. Demand shifts have clear and unambiguous effects on producer returns. If we assume a decrease in demand, a discount because New Zealand releases GMOs, then we must expect producer returns to decrease. Supply increases can result either in gains or losses, because the larger volumes are offset by lower prices. Which effect prevails is an empirical question. Our modelling suggests that the two effects largely cancel each other, with net small gains in producer returns.

Figure 6.3: Impact on producer returns of expansion in supply



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7 Conclusions on Economic Outcomes

While it would appear the two sets of model results are in parts providing differing pictures, much of these differences can be explained through differing parameter settings and modelling framework. In particular:

- the agricultural trade model provides a far richer detail within the agricultural sector and the commodities produced, as well as explicitly dividing GM and conventionally-produced commodities
- the foreign consumer preferences imposed by the agricultural trade model are explicitly modelled as a preference for conventionally-produced commodities
- the foreign consumer preferences imposed by the economy-wide model follow from the purchase behaviour questions in the surveys and so are explicitly modelled as a preference for products from countries without GMOs present
- the sensitivity of the foreign consumer to price differentials incorporated in the economy-wide model also follow from the purchase behaviour questions in the survey and consequently are larger than those incorporated within the agricultural trade model
- the productivity improvements imposed in the agricultural trade model incorporate explicit assumptions concerning uptake of the GM technology, while this consideration remains implicit within the economy-wide model which imposes an overall productivity assumption (net of regulation, containment, labelling and other costs).

The range of experiments performed using the two economic models signal a range outcomes in terms of economic impact.

In particular, given the range of productivity and demand preference shifts modelled, the impact of releasing a crop or biocontrol based GMO in New Zealand can result in both negative or positive overall economic outcomes. Critical elements in determining these results can be summarised as:

- the extent to which the purchase decisions of foreign consumers for New Zealand goods and services is dominated by their desire to buy from a country where there are no GMOs released. Where the survey responses are reflected by actual purchase behaviour (as has been modelled), such behaviour has significant and substantial negative consequences for New Zealand's conventional export commodities and, consequently, the wider New Zealand economy. If actual purchase behaviour represents a fading effect from stated intentions, the situation for New Zealand is more positive. If purchase behaviour is amplified by market gatekeepers, the result will be more negative.
- the extent to which the purchase decisions of foreign consumers for New Zealand goods is influenced by price differentials between commodities from other countries. Where the survey responses are reflected by actual purchase behaviour (as has been modelled), this behaviour can significantly bolster New Zealand commodity exports where GMO-based productivity improvements allow such price differentials in favour of New Zealand products to emerge.

- the extent to which GMO releases can improve productivity in the pastoral New Zealand agriculture sector. Where these improvements occur at historically comparable rates, significant gains to the New Zealand economy can be recorded. In this case though, the achievability of such gains are contingent on New Zealand overcoming quota, regulation and other market-access barriers to expanding New Zealand commodity sales in key markets.

Furthermore, given the range of productivity and demand preference shifts modelled, the impact of foregoing the release of GMOs in New Zealand can also result in both negative and positive overall economic outcomes. Critical elements in determining these results can be summarised, again, as:

- the extent to which the purchase decisions of foreign consumers for New Zealand goods and services is dominated by their desire to buy from a country where there are no GMOs released. Where the survey responses are reflected by actual purchase behaviour (as has been modelled), such behaviour has significant and substantial positive consequences for New Zealand's conventional export commodities and, consequently, the wider New Zealand economy. Again though, the achievability of such gains are contingent on New Zealand overcoming quota, regulation and other market-access barriers to expanding New Zealand commodity sales in key markets.
- the extent to which GMO releases can improve productivity in our competitor countries. Where these improvements occur at historically comparable rates, significant negative impacts on New Zealand commodity export volumes arise can arise. Similarly, if market gatekeepers do not act against specific applications of GM, then foregoing such applications would amplify these negative impacts.
- the extent to which alternative (non-GM) uses of biotechnology (and other technology enhancements) are available and/or successful in improving productivity.
- the extent to which the purchase decisions of foreign consumers for New Zealand goods is influenced by price differentials between commodities from other countries. Where the survey responses are reflected by actual purchase behaviour (as has been modelled), this behaviour can significantly compound the negative impact on New Zealand commodity exports where GMO-based productivity improvements in competitor countries allow such price differentials against New Zealand products to develop.

Finally, if the development of GMO-based proteins for human medicine in New Zealand leads to the quantum of reduction in demand for New Zealand exports reflected from the survey results, then protein exports of around $200m would be required to offset those changes in consumer demand.

The degree of uncertainty surrounding these three critical elements, ie.

- the proportion of foreign consumers that exhibit a clear preference for conventional products, irrespective of price
- the proportion of foreign consumers that 'remain in the market' following GMO release and the extent of their sensitivity to price differentials
- the productivity gains (net of regulatory, confinement, labelling and other costs) from the release of GMO, compared to the productivity gains achievable through non-GM uses of biotechnology and other technologies that remain available

... is considerable.

All the model experiments indicate clearly that the modelled economic outcome for New Zealand is extremely sensitive to the size of each of these critical elements. As such, reducing the degree of uncertainty surrounding these elements is a prerequisite to reaching a conclusive statement on the economic outcome of either a GMO release or a policy foregoing GMO release.

8 Critical Factors Determining Economic Outcomes

Assessment of the detailed results of the economic experiments has enabled us to conclude that there exist four critical elements underlying the economic risks and opportunities from the release of GMOs in New Zealand.

(1) The magnitude of the change in demand for New Zealand goods and services

This factor describes the extent to which the purchase decisions of foreign consumers for New Zealand goods and services is dominated by their desire to buy from a country where there are no GMOs released. If the survey responses are reflected by actual purchase behaviour, such behaviour has significant and substantial negative consequences for New Zealand's conventional export commodities and, consequently, the wider New Zealand economy. There is uncertainty attached to actual behaviour justifying the close monitoring of consumer attitudes and purchasing. International research indicates that when faced with actual purchase decisions at point-of-sale, consumers' reactions will be different from what they say they would do in 'willingness to pay' surveys.

The price-quality characteristics of the product displayed, relative to those from other countries can assume a powerful if not predominant influence in the product choice for many consumers. It is also unlikely that consumers would know, or bring-to-mind at point-of-sale, the GM attributes of New Zealand in other contexts, and yet in the survey context, of necessity this has been brought specifically to their attention.

The origin country of products is not necessarily identified on supermarket shelves. It is likely that the labelling of products as GM or non-GM could influence consumer behaviour rather than the country of origin.

(2) The response of foreign consumer demand to price changes

This factor describes the extent to which the purchase decisions of foreign consumers for New Zealand goods are influenced by price differentials between commodities from other countries. This price responsiveness can allow New Zealand to counteract loss of sales to CGI-sensitive market segments by reducing prices and thus increasing sales in other market segments.

(3) The access of New Zealand goods to global markets

Associated with the consumer reactions to the release of GMOs in New Zealand, described by the first two factors, is the institutional, regulatory, commercial aspect of access for New Zealand products to particular world markets. In many markets the actions of regulators and gatekeepers (for example, retailers, wholesalers, traders, buyers for supermarket chains and others) can either mirror, amplify or in some ways modify the effective consumer demand.

(4) The opportunities for productivity enhancements

This factor describes the extent to which GMO releases can improve productivity or open new opportunities in New Zealand industry. If these productivity improvements, leading to cost reductions, occur at historically comparable rates, significant gains to the New Zealand economy can be recorded. In this case though, the achievability of such gains are contingent on New Zealand overcoming quota, regulation and other market-access barriers to expanding New Zealand commodity sales in key markets. On this production side there are potential benefits from a portfolio of GMOs with a range of effects on productivity, product quality and the environment.

The degree of uncertainty surrounding all four elements is considerable. As such, it remains important for New Zealand to manage GMO-related activities for the benefit of all New Zealanders. Progressively reducing the degree of this uncertainty over time will be a prerequisite to reaching a conclusive statement on the economic outcome of either a GMO release or a policy foregoing GMO release.

The results of the economic experiments confirm that establishing actual (as opposed to surveyed) purchase response to GMO release is pivotal to determining its impact on the New Zealand economy. Similarly, greater information aimed at confirming the actual (as opposed to asserted) productivity gains from GMO release is the other critical element that is a pre-requisite for a conclusive determination of the economic impact.

Appendices

The appendices comprise:

- literature review
- survey questionnaire
- NRB survey consumer results
- NRB survey gatekeeper results
- Lincoln survey results
- economy-wide model experiments
- LTEM model details.

These appendices are available at the website of the Ministry for the Environment: www.mfe.govt.nz.