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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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:

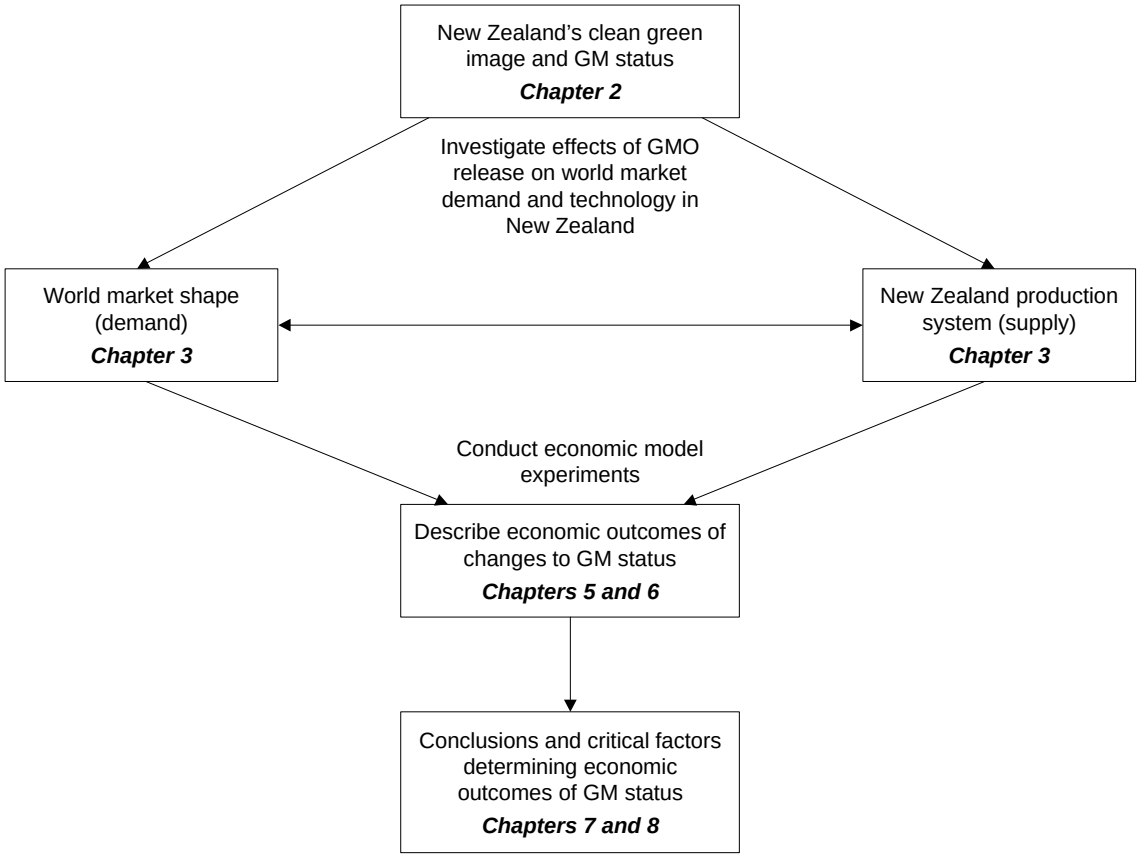
- the extent of New Zealand's CGI
- the effect that releasing GMOs affects New Zealand's CGI.

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).

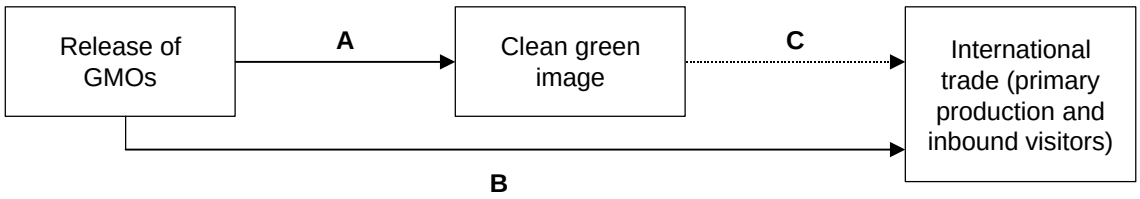
It is not possible to identify at this time all potential opportunities for the application of GM in New Zealand, nor to specify the economic effects and model the impact of them all on the New Zealand economy. What can be done is to identify a small number of types of GM opportunities, to specify a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

[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.

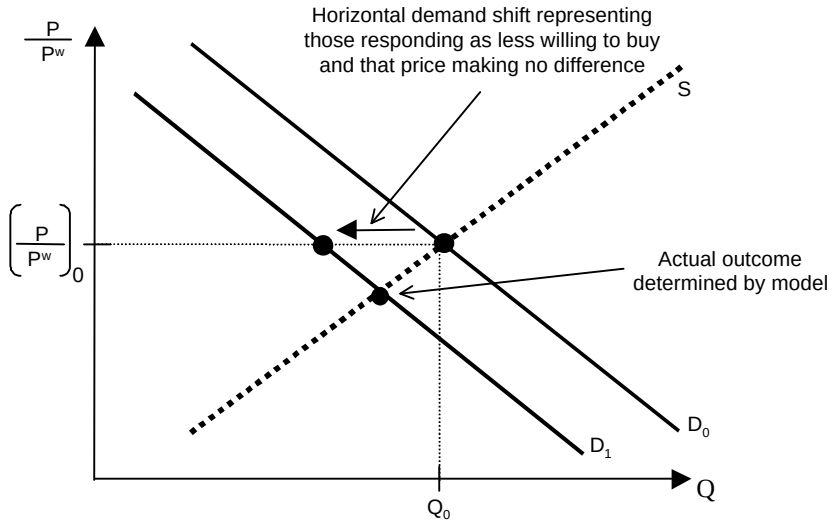
[5] Based loosely on the overall sample sizes of each survey, ie. 444 and 93.

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.

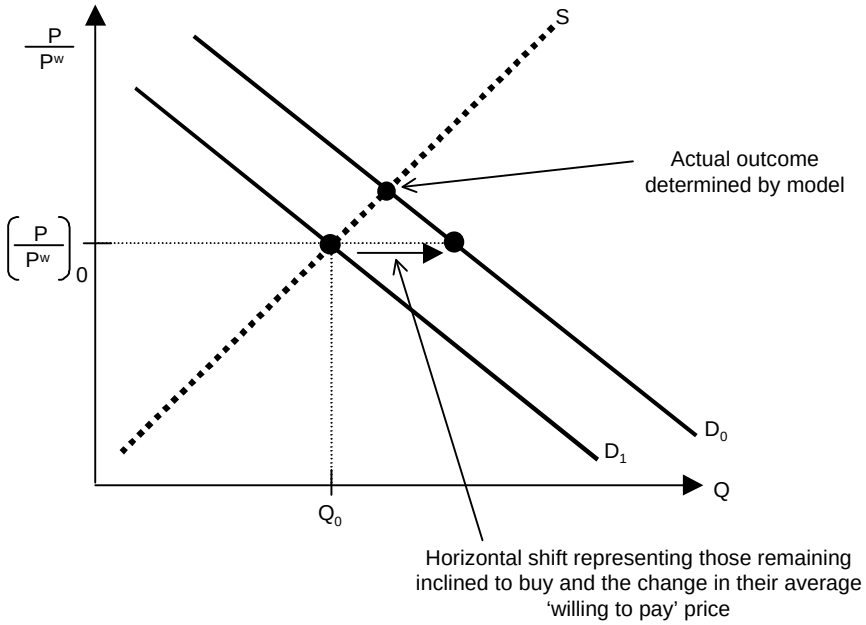
The horizontal shift consistent with such a movement was calculated. Figures from the two surveys were combined (using the 80%:20% proportions as above) to determine the overall demand curve shift of 34.3%. These were imposed in the 'no GMOs' scenarios, after adjustments to allow for the proportions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

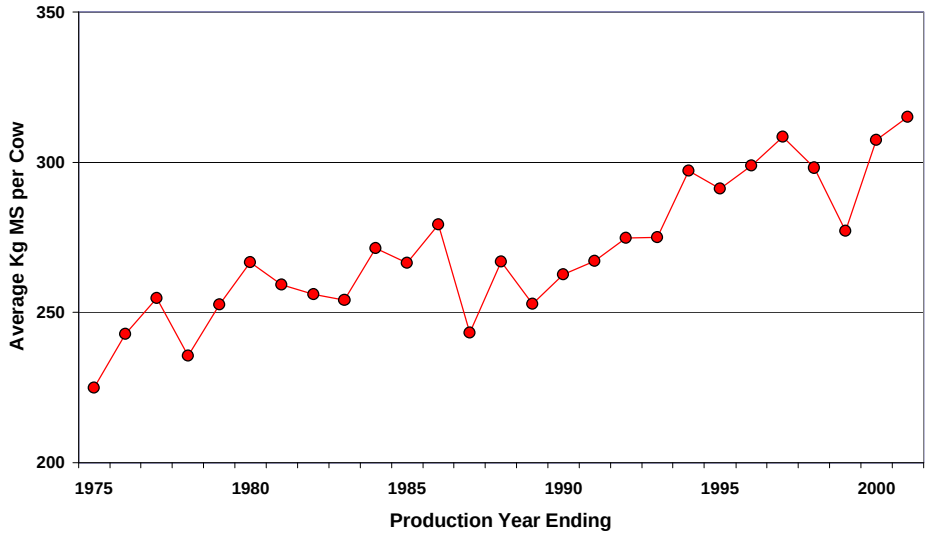
In New Zealand pastoral agriculture, genetic improvement has been pursued from soon after the importation of exotic species for agricultural production in the nineteenth century. Producers have utilised techniques like cross-breeding and selection to generate modified exotic breeds better-suited to the 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

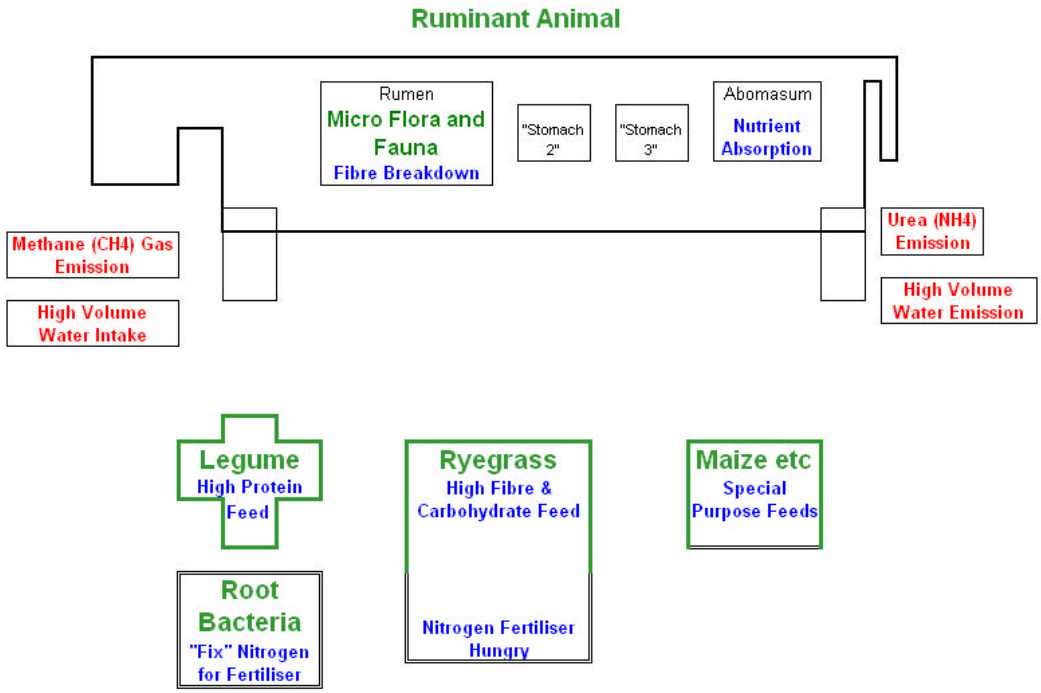
Pastoral agriculture is based on production from a system utilising both plants and animals that interact in a complex production system. The main plant and animal organisms and their functions are stylised in Figure 4.2 below.

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

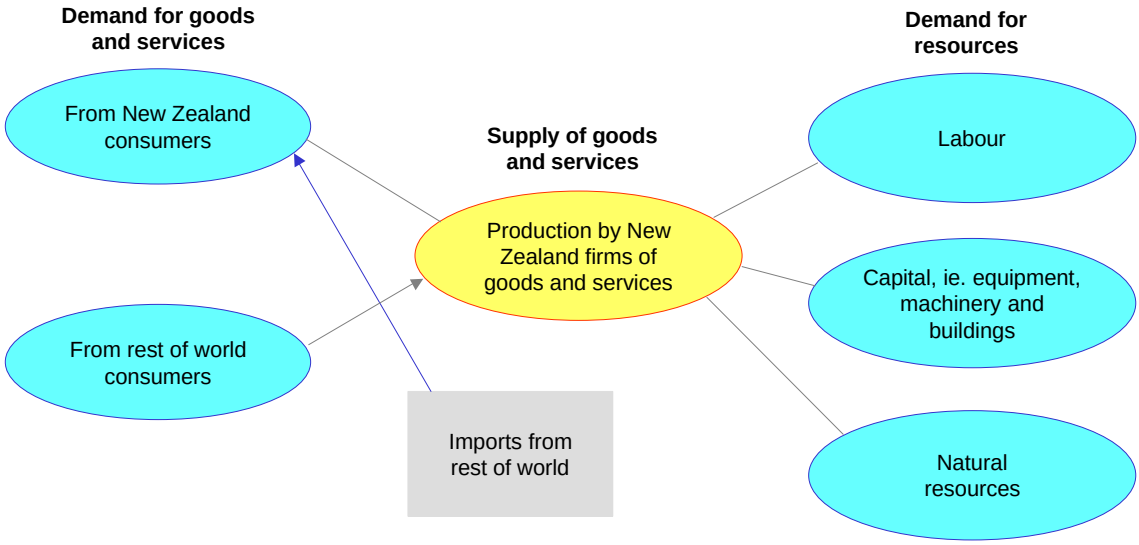


Figure 5.1 illustrates that the demands for New Zealand goods and services arise from two sources – namely from New Zealand consumers and consumers in the rest of the world – the latter being New Zealand's exports to the RoW.

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.

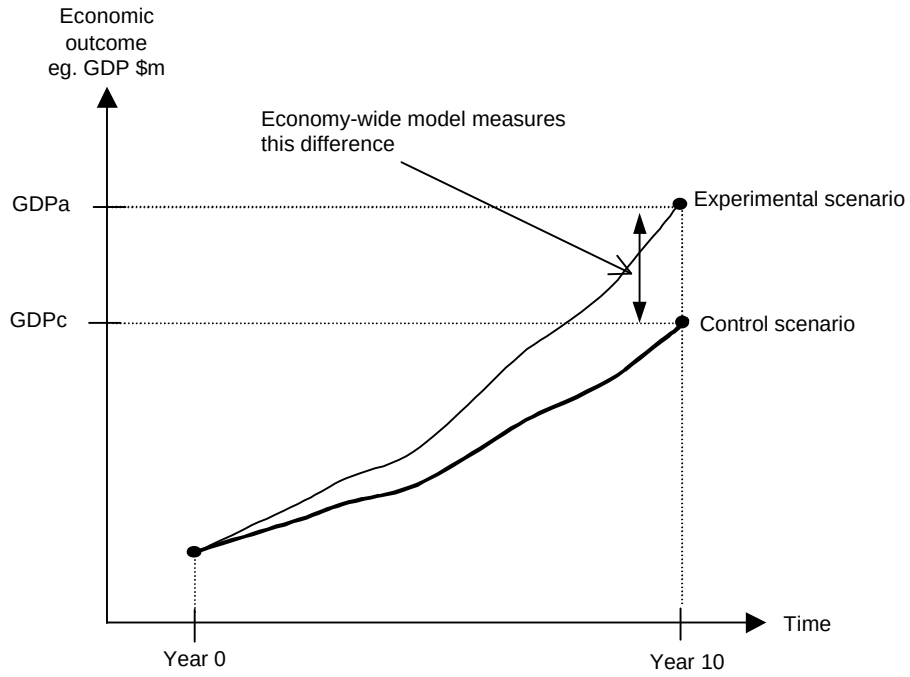
Note that in reality these three forces would not act in isolation. In these cases, the results of the model experiments provide information about the magnitude of the impact (given the size of the single original force) as well as details concerning inter-sector consequences.

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

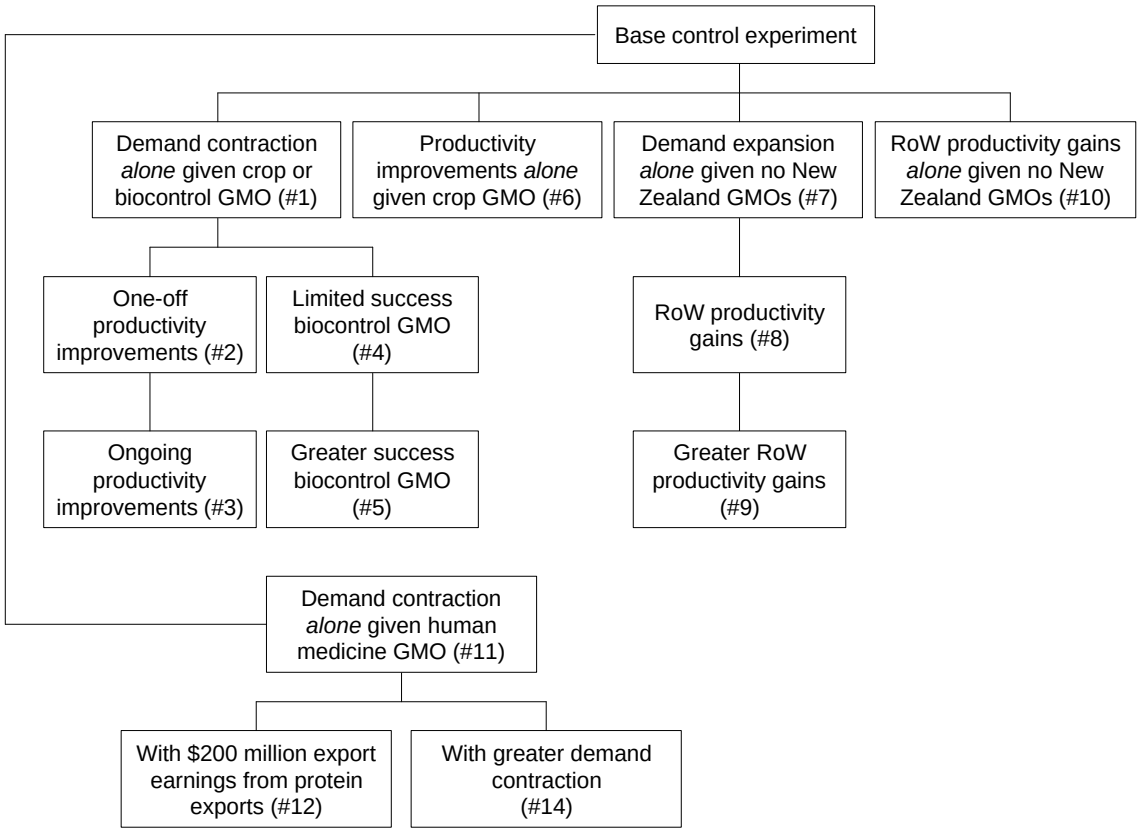


The model measures the difference between, for example, the level of GDP 10 years hence in the *control* scenario and the level of GDP 10 years hence in the experimental scenario. In particular, note that the percentage changes presented in the results tables are *not* differences in per annum growth 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			With RoW productivity gain *alone*	= #10 with 50% *smaller* export demand expansion	= #10 with 50% *larger* export demand expansion
	Alone	With *moderate* productivity gain in RoW	With *greater* productivity gain in RoW			
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.

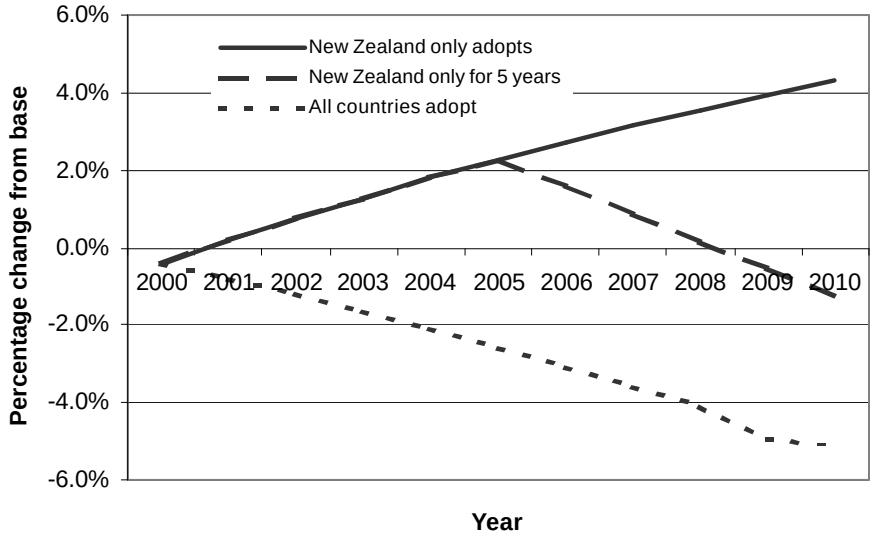
Table 6.3: Change in producer returns from a 25% productivity increase

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.

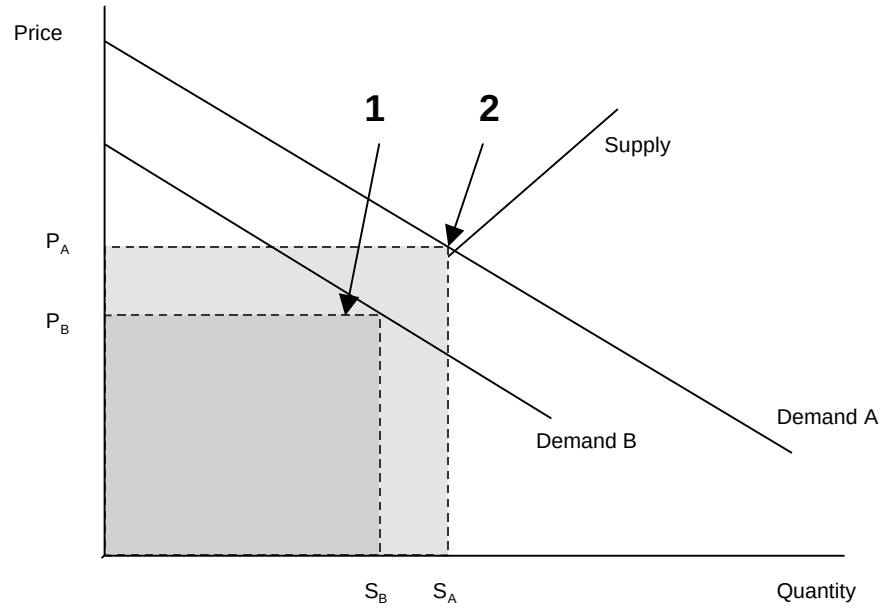
Producer returns were more responsive to demand changes. Discounts on New Zealand products resulting from adoption of GM technology clearly reduced New Zealand producer returns. Any premium that New Zealand could capture from foregoing GM release, preserving and expanding on its CGI, clearly resulted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

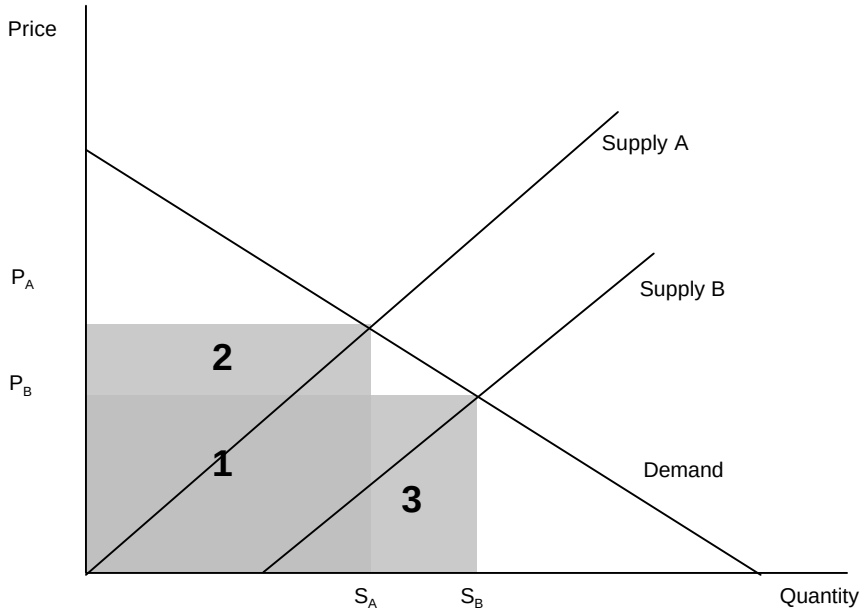
Figure 6.2: Impact on producer returns from reduction in demand



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



References

Foltz JD, Chang HH. 2002. The adoption and profitability of rbST of Connecticut dairy farms. *American Journal Agricultural Economics* 84(4): 1021–32.

Cagatay S, Saunders CM. 2003. *The Lincoln Trade and Environment Model: An agricultural multi country, multi commodity partial equilibrium trade model*. Research Report No 254. AERU, Lincoln University.

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.

Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 1
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

Background Literature Review[1]

March 2003

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Contents

Introduction

This review focuses on several key areas that inform survey and modelling activities in this project. While there is a lot of literature and media reporting on the issue of commercial use of genetically modified organisms (GMOs), in the last few years, some substantial publications have reported on the first round of sustained economic analysis of genetic modification (GM) products in agriculture. Such literature moves the discussion forward considerably from 2000, when the Royal Commission on Genetic Modification determined that there were a number of unanswered questions about the economic importance of GM to New Zealand. In broad terms the following review primarily examines consumer, production, and trade issues relating to biotechnology. It is specifically directed at GM technologies, but much of the relevant literature only addresses GM as a subset of the wider group of biotechnologies. The literature is very uneven with considerable material being available on consumer perceptions of agriculture, medicine and food uses of biotechnology, with associated material of relevance to tourism. However, the key issues for this report which link environmental uses to economic activity can be informed by only a small body of literature. While this review does not set out to document comprehensively every possible economic issue around GM, it does cover the key areas of literature that inform the survey and modelling activities of the Clean Green Image project.

1. The Clean Green Image in New Zealand

The origins of the concept of a 'clean green' image for New Zealand is actually comparatively recent. Claudia Bell (1996) argues that the conscious attempt to label New Zealand as 'clean and green' commenced in the mid-80s around the time of New Zealand's shifting global political relations surrounding the Rainbow Warrior incident (1985) and the passing of the New Zealand Nuclear Free Zone, Disarmament, and Arms Control Act (1987). Bell notes that the term 'clean and green' originated as an alternative political slogan, but was adopted by mainstream political parties during this period in the mid-80s. Moving the slogan into commercial branding occurred soon after. The two key events typifying this commercial shift were the Brisbane Expo (1988) and the Seville Expo (1992) – the Expo Commissioner in 1992 using the slogan: 'We're clean and green. We produce food that doesn't glow in the dark' (Bell, 1996: 96-97).

It is not long after this that researchers began to investigate the CGI in terms of its marketing and consumer significance. The initial research into this issue was conducted by Gendall et al. (1993). This research clearly related the CGI to nuclear free and broader environmental issues – predating a later focus on GM. Their report showed that the CGI had become a widely recognised concept among New Zealanders, but that 42% thought it was a myth. Citing this report, later researchers (eg. Hughey et al. 2002) moved away from an examination of a generic CGI preferring to focus on specific resource sectors.

The first extensive attempt to evaluate the economic value of the CGI was commissioned by the Ministry for the Environment (MfE) in 1999. The resulting report: *Key Opportunities and Risks to New Zealand's Export Trade from Green Market Signals* (Woodward Clyde: Wellington), provided a very useful analysis of what might be involved in the generic concept of the CGI and how that might be unpacked in terms that would enable more concrete economic analysis. In particular, they moved beyond the term CGI and argued that for economic analytical purposes what was being considered was: 'green market signals'.

These market signals comprise:
• emerging trade pressures in terms of overseas government deployment of environmental criteria in trade access;
• the emergence of Environmental Management Systems;
• the development of eco-labelling schemes;
• buyer group pressure gatekeeping the market; and,
• consumer sentiments around food scares, risk, environmental criteria, and food safety.

The next stage after Woodward Clyde (1999) was to attempt some actual economic modelling of sector specific values and risks around loss of environmental image. A subsequent MfE funded study was undertaken by PA Consulting Group (*Valuing New Zealand's Clean Green Image*, PA Consulting Group, 2001). The three sectors modelled in the PA Consulting Group (2001) were:

- Dairy exports under the scenario of a worsening environmental image for New Zealand.

• Inbound Tourism under the scenario of a worsening environmental image for New Zealand.
• Organic agriculture under the scenario of uncontrolled release of GMOs into the environment.

While the results were instructive – clearly making a case that the CGI was important economically to New Zealand – the third of these scenarios was hampered by methodological difficulties in assessing the emergent organic agriculture sector and its market gatekeepers.[2] As a result, (and consequent on the GM versus organic scenario) some of the broader questions about the economic impact of GM on the New Zealand economy remained unanswered.

Alongside the MfE sponsored research, a body of university research undertook an analysis of the kinds of green market signals identified in Woodward Clyde (1999). Cook et al. (2001) and Hughey et al. (2002) undertook two surveys on the CGI and the New Zealand environment. They generally agreed with PA Consulting (2001) that the CGI was important economically for NZ. Their five key results were:

1. New Zealanders thought NZ was clean and green.
2. Respondents thought our environment was good, but emerging trends were not positive.
3. Farming is increasingly seen as a source of environmental problems.
4. Different ethnicities in NZ differed significantly on all views.
5. Pollution is the main concern. Biodiversity and GM are less compelling.

These papers and commissioned reports highlight an interesting set of issues for policy advisers and researchers. While this body of work does indicate an economic value for our CGI, this conclusion is based on relatively few analyses and raise more questions than they answer. In particular, Woodward Clyde (1999) suggested a range of issues that actually cluster together under the single concept of the CGI which include consumer sentiments, market gatekeepers, trade politics, emergent new management systems in primary production and new labelling schemes in key markets. Likewise, the PA Consulting Group (2001) report suggested some important emergent issues for the economic impact of GM in primary production, but was only able to conduct a partial review of one minor aspect of primary production in New Zealand.

In order to unpack this cluster of issues around the CGI and the economic impacts of GM, the following sections review literature relating to:

• The way in which consumers perceive GM, public opinion polls, surveys and qualitative analyses of changing consumer sentiment.

[2] Market gatekeepers involve a number of layers of entry to markets. These include regulators at the border, distributors, manufacturers who import raw ingredients, and, most importantly, retail chains who make decisions about what kinds of products they stock, and also what the composition of their 'own brand' products will be.

• Economic analyses of GM, including: evaluations of farm level performance of GM; levels of grower adoption of GM; trade performance of GM; and the macro-economic modelling of GM in New Zealand.
• Two country case studies: Canada and Switzerland. In both these countries, there are strong consumer perceptions of high environmental values and yet both are positioned within the development of GM technologies.

2. Consumer Perceptions of GM

The understanding of consumer perceptions as of the end of 2000 is summarised in Campbell (2000). That review considered 61 publications on consumer perceptions of biotechnology up until 2000. 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.

2.1 Public Opinion Surveys

There are a range of possible sources of information on consumer/public understandings and perceptions of biotechnology (for example, internet sites, academic journals, book chapters, technical reports, customer surveys, public opinion polls in newspapers and privately funded consultants' reports for large industry). There is a wide variance in quality of these sources.

There are three main kinds of literature:
• A large number of marketing style surveys and opinion polls. These sources are of extremely variable quality but can be useful as indications of drifts in public opinion without, however, being able to offer explanations as to why these may occur.
• Psychosocial and quantitative social science surveys. These have a more rigorous design but are very focused at the individual-level, thus missing broader social dynamics.
• Finally, there are the more speculative social science pieces which examine larger social trends in an effort to explain their effect on individual and group behaviour.[3]

This literature is restricted to only a few geographical regions: predominantly North America and Europe.

[3] This review will deal directly with this broader social science literature. While it is clear that there are broader social trends, interest groups, and media processes that act as key influences on consumers, the literature surrounding them is broad. A preliminary analysis of some of this literature is presented in Campbell et al. (2000). There are also important issues of risk. Green (2000) reviews case studies of different regimens and perceptions of risk around new technologies.

In general, care should be taken in analysing trends from any *one* of the categories of data previously described and a more reliable picture is likely to emerge from careful consideration of all three categories.

As there have been so many opinion polls and surveys, the key items of literature reviewed here are those that summarise the findings of multiple surveys or polls.

Zechendorf (1994) reviewed 24 surveys and opinion polls from different countries over 10 years and observed (despite the disparity between methodologies) that acceptance of the technology was different for various applications and was moderated by the individual's level of knowledge of biotechnology, their perception of risk, and their areas of ethical concern (for example, applications for drug use were preferred over interference with food or animals). Zechendorf also noted that those individuals who increased their knowledge of biotechnology also tended to become more accepting of it.

In 1998, Norton reviewed sixteen surveys and opinion polls from Australia, New Zealand, Northern America and Europe over the preceding eight years and described similar trends, in particular, the tendency to differentiate between the acceptability of certain applications of biotechnology (e.g. there was more distaste for manipulation of human material than for animal material). There was also concern for the unintended consequences which may have been associated with the technology and a lack of confidence in the ability of regulatory bodies to manage these risks.

Kamaldeen and Powell (2000) have reviewed polls of quite varied sophistication and rigour to gather North American opinions on biotechnology in relation to recent international opinion polls. They illustrate that concerns over biotechnology and GM food in particular are not as significant for North Americans as they are for Europeans as around 61% of Canadians feel comfortable with biotechnology as a general concept while 39% do not. However, 59% of the Canadians polled also saw GM *food* as a negative application of the technology in contrast to the 39% cited as being not comfortable with the technology in *general* (Angus Reid 2000 cited in Kamaldeen and Powell 2000), suggesting a similar differential response to applications of the technology as has been noted in other western countries.

In the New Zealand context, Cook et al. (2000) completed a review of seven studies of New Zealand attitudes to GM in food production, including a four-study work by Gamble et al. (2000), which were carried out over the period 1990 –2000. These studies show that knowledge of GM has increased over time and that acceptance of the technology remained rather higher than in other areas of the world until 1998 when it began to diminish (Macer 1994; 1998 cited in Cook et al. 2000). The differential response to the various applications of the technology seen in other parts of the world are also evident here (plant applications being more acceptable than animal or human interventions). Concern for the technology is based on food safety issues, environmental effects and its "unnatural-ness". A recent report by Gamble and Gunson (2002) found that GM food safety was still moderately important, and that around one-third of consumers claimed to

have changed their purchasing behaviour because of GM. They also found the expected variation of consumer responses to different applications of the technology.

A specific body of work by the researcher Thomas Hoban has extensively examined consumer perceptions in various countries, especially the United States (US) (Hoban 1989, 1994, 1995, 1996, 1997, 1999a, 1999b, 2000). His general findings prior to 1997 indicate a lower level of concern over biotechnology in the US than in Europe with people prepared to try varieties of GM food which have been engineered with specific benefits. However, there is still a differential response to the acceptability of certain applications of the technology (medical and crop technology are more popular than animal, food and fish applications).

The situation regarding European perceptions of biotechnology is best understood from the useful Eurobarometer polls (http://www.europa.eu.int/comm/dg10/epo/eb.html). Eurobarometer 52.1 was carried out in 1999 and included around 16,000 people from member states of the European Union (EU) on the topic of biotechnology. Results show that consumers were concerned about their lack of knowledge of biotechnology and they exhibited a noticeably decreasing trust in all available sources of information on biotechnology although consumer groups (26%), and medical (24%) and environmental organisations (14%) were regarded as the most trustworthy. Differential acceptance of the applications of the technology was still apparent with food applications being least acceptable and disease detection the most acceptable while medical and pharmaceutical applications were also viewed positively.

Since the 1999 Eurobarometer Poll, there have been a very large number of polls conducted in a variety of countries – clearly reflecting the significance of GM as a public and political issue. Accordingly, this literature review evaluated 37 polls conducted since 1999 (see Bibliography).[4]

These 37 polls varied according to a number of factors, including country of origin, quality, methodology, and findings. Most are based in North America (the main producer of GM crops) or Europe (the main opponent of such crops) - the two sides of the GM transatlantic debate - and in developed rather than developing countries. Those surveys that do focus on developing countries, highlight a major difference on the importance placed on possible health risks, with developing countries placing much less importance on these. The comparisons of several developing countries also established that the political, cultural, and historical backgrounds of each individual country significantly influences the issues brought up in the national biotechnology debate.

One set of polls – the International Food Information Council (IFIC) Polls (no date) – suggest that opinions are not changing. These were conducted by the Wirthlin Group until January 2001 and latterly by Cogent Research and do indicate that acceptance of genetically modified food (GMF) remained fairly consistent from 1997 to the most recent survey in August 2002. While these polls are based on a relatively unrigorous methodology, they do show constant patterns of consumer resistance to GM food and

[4] 16 new polls were reviewed and the remaining 21 were summarised in articles.

differential acceptance of other biotechnologies – particularly in diagnostic medicine and pharmaceutical applications. These results are in accord with the broad trends in the Eurobarometer and in the surveys summarised above in Zechendorf (1994), Norton (1998) and Kamaldeen and Powell (2000).

2.2 Psychometric Evaluations of Consumer Behaviour

One more specific methodology for understanding consumer behaviour is that which involves the psychometric evaluation of consumer behaviour. In the study of consumers and GM, the main body of research has been conducted by Lyn Frewer and her associates.

Frewer et al. (1994a, 1994b, 1995, 1996, 1998, 1999) have used psychometric surveys of (mostly British) consumer understandings of risk and psychological models of communication in relation to this topic. Their work also confirms a differential response to the acceptability of GM technology based on its applications, with negative responses to work on human and animal DNA while work on plants and micro-organisms being seen more positively. The decision by their subjects to view certain applications as negative was sometimes mediated by the perception of the benefit or need associated with the application. They also note significant distrust by their subjects of the government and industry as sources of information on biotechnology and demonstrate that medical doctors and consumer groups are regarded by the public in the United Kingdom (UK) as more trustworthy sources (Frewer et al. 1999). They also describe some cultural differences in responses to their surveys on concern over biotechnology with the UK sample expressing concern over the risk associated with the technology while, for the Italian sample, ethics appeared to be the more problematic aspect of biotechnology (Frewer et al. 1999). This work on risk, confirms both the broad trend noted above (country variability, differential acceptance of different applications of biotechnology, persistent questions and trade-offs of risk and benefit), but it is also limited by the lack of engagement with broader social and economic processes.

2.3 Discussion: Consumer and Public Opinion Surveys and the PABE report.

While the surveys and opinion polls reviewed above do indicate some broad trends, as well as clearly showing the variability between different countries, their methodological approach necessitates a limited view of consumer and public perceptions and actions. More recently, however, the PABE report (Marris et al. 2001) has highlighted the way in which intensive qualitative research can generate insight into some of the complex ideas and processes that underpin consumer perceptions of biotechnology – including GM.

Due to its importance, the PABE report will be discussed in detail.

One central finding of the PABE report identified that stakeholders involved in the GM debate have misunderstood public responses to GM. This is given as a key cause of the ‘current impasse’ in that debate. The PABE report argues that public responses to GM are usually explained by ‘decision-makers’ in terms of the public having: ‘a lack of

knowledge' or 'ethical concerns'. This kind of explanation does not acknowledge the 'social, cultural, and institutional factors shaping these concerns' (Marris et al. 2001:7). Instead the PABE findings are complex and blur common distinctions (such as those made between 'real' and 'perceived' risk), illuminating societal concerns and then contrasting these with official views of public perceptions.

The report presents two types of results about public perceptions:

- -Perceptions of GM among ordinary citizens were studied in focus groups held in five EU member states: France, Germany, Italy, Spain, and the UK (total of 55 sessions).
- -Perceptions of public responses to GM among stakeholders (actors engaged in the GMO controversy) were studied using interviews, participant observation and document analysis.

A comparison of these results identifies a 'gulf' between stakeholder views of the public and public views expressed in the focus groups. The main conclusion identifies the need for the development of a 'more constructive and satisfactory debate on agricultural biotechnology'; which would include recognition by policy makers that the behaviour of institutions involved in the management of GMOs, as well as public behaviour, are sources of the problem. While this finding is not of direct relevance to this project, within the PABE findings are a number of points of relevance to understanding consumers and GM.

An important finding was the overwhelming similarity of focus group findings across countries, groups, and time. Contrary to expectations, there was a broad similarity in the repertoire of arguments mobilised by focus group participants in all five countries. This result ran strongly counter to all the surrounding survey activity, which highlighted differences between countries – suggesting that some of those differences might be due to different methodologies rather than real differences. However, there still were inter-country differences, especially when the combined effect of public perception and regulatory process is taken into account. The PABE also only studied EU countries.

The project identified 10 key 'myths' which stakeholders held about public perceptions of biotechnology. Four of these are directly relevant to a consumer analysis:

Myth: People are either 'for' or 'against' GMOs.
Myth: Consumers accept medical GMOs but refuse GMOs used in food and agriculture.
Myth: Consumers want labelling in order to exercise their freedom of choice.
Myth: It's the fault of the BSE crisis. Since then, citizens no longer trust regulatory institutions.

The findings of the focus groups challenged these myths. The PABE research found that although ordinary citizens are largely ignorant of scientific facts concerning GMOs, this lack of knowledge does not explain their response to agricultural biotechnologies. While scientists and policy makers tend to assume that specialised scientific knowledge is

required for the public to have a rational opinion about GMOs, focus group participants utilised three types of knowledge in supporting their arguments about GMOs:
1) Non-specialist knowledge about the behaviour of insects plants and animals.
2) Knowledge about human fallibility from daily experience.
3) Knowledge about the past behaviour of institutions responsible for the development and regulation of technological innovations and risks (the most predominant type of knowledge used).

Overall, participants did not express opinions 'for' or 'against' GM but were ambivalent, identifying both positive and negative aspects of agricultural biotechnology. Participants did distinguish between medical and agricultural applications of GMOs. However issues such as access to information and regulation were important in influencing this distinction. Participants were sceptical about some benefits claimed for GMOs, (for example, claims that they could 'feed the world' were viewed as a marketing ploy). Participants wanted GM food labelled to allow consumers to 'send a message' through boycotts, and as a demonstration that the promoters have nothing to hide.

The presumption that people are either 'totally for' or 'totally against' GMOs is also challenged by some surveys being undertaken around the same time as the PABE exercise, especially those that employed focus groups. Rather, respondents often held ambivalent views of biotechnology as a whole, accepting some applications but rejecting others. Medical applications of biotechnology were generally more accepted than agricultural applications. In contrast, agricultural applications are seen to benefit large companies financially, whereas the public at large is put at risk.

In conclusion, the PABE report, when contrasted with the other surveys evaluated in this review, does challenge the degree to which behaviour varies by country within the EU. However, it does provide important substance to a number of other trends: the strength and durability of public concern, the variable acceptance of different uses of biotechnology, the agriculture/medical division, and the importance of regulatory contexts which build/undermine trust. Due to the methods used in the PABE project, the focus group participants focused almost entirely on medical/food uses of biotechnology.

2.4 Economic Measurements of Consumer Demand

Economists have tried to measure consumer demand with several tools. Their contingent valuation (CV) surveys do not indicate anything new about consumer sentiment but do serve to suggest the strength of demand for non-genetically-modified food (non-GMF). A CV survey of US and UK consumers assessed their willingness to avoid (WTA) GM breakfast cereal (Moon and Balasubramanian, 2001). Both countries had consumers who would pay to avoid GM cereal. However, the average WTA – the increase in price consumers were willing to pay in order to avoid GM cereal – was higher in the UK than in the US (56% versus 37%), which is consistent with opinion poll results.

Choice modelling is another tool for measuring WTA. A choice modelling survey of Western Australian consumers found that genetically modified food would need to sell at

an average discount of 20% to 47% in order to offset negative attitudes (James & Burton, 2002). UK consumers were even less disposed to buy GM (Burton 2001). Respondents were grouped into six categories according to gender (male or female) and how often they purchased organically grown food (Infrequent, Occasional, or Committed purchaser). All groups were willing to pay more for non-GM, from the lowest category at 26% to the highest at 468% (Burton et al. 2001).

The design of choice modelling surveys makes them useful for analysing trade-offs in a way that simple opinion polls cannot. However, they still do not indicate what respondents would do in a retail situation. To discover what consumers might actually do, economists have begun analysing market data. For example, Kiesel et al. (2002) analysed market data for milk and found that labels indicating the milk was produced without rBGH (recombinant bovine growth hormone) increased demand. They further found that the positive effect of labelling had likely increased over the period analysed, suggesting that resistance to the use of rBGH is not fading with time.

Because rBGH is a special case in which clearly labelled products with close substitutes have been widely available for years, economists have devised auction experiments to provide insights into responses to other GM foods. US Midwest consumers, given the chance to bid on GM and non-GM vegetable oil, corn chips, and potatoes, discounted the GM products by an average of 14% (Huffman et al. 2001). Another experiment with the same products indicated that tolerance for contamination by GM is non-linear: consumers discounted food containing up to 1% GMOs similarly to foods containing up to 5% GM (Rousu et al. 2002).

In a widely publicised report, Noussair et al. (2001) found that French consumers' willingness to pay for products labelled as containing GM ingredients fell by nearly 30% when such information was clearly shown to them in the experimental situation. However, they noted a strong tendency for the research participants to not read labels on food when such activity was not specifically directed by the experimental design. This was hypothesised to account for why consumer sentiment and consumer behaviour might be dissonant.

The effect of actual product experience was also assessed in a laboratory experiment (Grunert et al. 2002). Consumers were given cheese to taste (it had been earlier determined which cheese the subjects preferred, so that their tasting experiences would be positive). They were then told that the cheese was GM. The findings suggested that the positive experience with GM cheese made the subjects less negative about GM foods overall and reduced the importance of the issue of GM in their food consumption.

2.5 Consumers and Environmental Values

Environmental values are an important part of perceptions of GM food (Cook, 2000; Bredahl et al.1998). However, the relationship is not straightforward. Researchers found that favourable attitudes towards nature correlated with negative attitudes towards GM (Bredahl, 2001). More specifically, survey respondents did not agree that GM is

environmentally friendly (Small et al. 2002), and ecocentric respondents (those that value nature intrinsically) did not support GM (Siegrist, 1998). Likewise, those who felt that the costs of technological growth and energy consumption were too high tended to have negative attitudes towards GM (Sparks et al. 1994). In general, acceptance of GM was less likely when there is greater environmental risk (Small et al. 2001; Macer 1992). In fact, the Organisation for Economic Cooperation and Development (OECD) has attributed the lack of acceptance of rBGH outside the US to concern for animal welfare (OECD, 2000).

However, surveys that attribute environmental benefits to GM in agriculture find positive reactions. In the IFSC/Wirthlin Group/Cogent Research surveys, respondents were asked whether they would buy biotechnologically derived food that required fewer pesticide applications and whether they would buy biotechnologically derived food engineered to taste better or stay fresher. Consistently, respondents express more support for the biotechnology application that has an environmental benefit (IFIC 2002). Canadian, New Zealand, and Australian research has revealed a similar pattern (Sheehy et al.1998; Macer, 1994). Choice modelling highlights this trade-off: research in Western Australia found that respondents would purchase GM food at a 20% to 47% discount, but would also pay 36% more to reduce agrochemical use by 30% (James & Burton, 2001).

Environmental values seem to cut both ways. To the extent that GM may represent a perceived threat to the environment, they are less valuable to some consumers. To the extent that they are perceived to reduce environmental damage, they become more valuable.

2.6 Key Conclusions

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 is increasingly related to broader concerns about ethics, food morality, regulation and food safety, and the perceived politics of food trading. The first conclusion is therefore that there is likely to be resistance to GM food 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.

The second conclusion, however, is that there is a great degree of variability within this broad trend. Levels of consumer concern vary by country and 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.

Apart from these two conclusions, it is also worth noting that there is a complete absence of literature directly targeting the key issue in this research project: does the presence of some GM exports influence consumer's *stated* buying behaviour for other non-GM

products? Although there is an absence of evidence showing that consumer preference for non-GM products has affected purchase behaviour in non-GM products from countries that grow GM, there is a clear gap in the existing knowledge around GM, justifying the survey and modelling work undertaken in this project.

3. Economic Issues for GM

This section covers some of the key issues in relation to economic issues and GM. Specifically reviewed are:

- the impacts of GM in primary production in the US is reviewed;
- the level of grower adoption of GM;
- studies of the trade performance of GM;
- the specific macro-economic modelling of GM in New Zealand; and
- the trade and market strategies of some of our key markets.

The following literature is 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).

3.1 Impacts of GM in primary production

The economic impact of the commercial release of GM depends upon the combined responses of both producers and consumers to GM in the international trading environment. Initially, this section assesses the impact of GM on producers in isolation and then turns to the trade impacts. As the commercial release of GM food crops has mainly been in the US, most of these studies relate to that country.

The following review examines the key GM food crops (meaning crops for human consumption). This is only one area where GM developments have occurred. Two others are GM cotton, and GM crops destined for animal feed. The main purpose of this literature review is to provide underpinning information for scenario development. The relevant scenario for this section involves human food consumption – not fibre or animal feed production.

The current commercial release of first generation GM food affects the production system. The main commercially released GM food crops are insect-repellent maize and herbicide-tolerant soybeans and canola. Thus, most of the current benefits of GM come from the supply side and relate to potential increases in yield and/or reductions in costs.

Given that GM field crops were well into production in 1996, it is not surprising that the first on-farm evaluations of crop performance commenced a few years later. The results from various early studies (1998-1999) show that the impact of GM production on yield varies according to the crop type. In the case of soybeans and canola there seems to be little change in yield, and in the case of soybeans there have actually been falls recorded in the yield of the GM crop compared with GM-free. This result is perhaps not surprising as these GM soybeans and canola are not targeted at the productivity of the plant but rather at changes in input use, so expected gains should be from savings in input costs. In the case of maize there are reported increases in yield which vary according to the level of insect infestation. These gains in yield have been estimated to range from 0.26 to 1.88 tonnes per hectare depending upon the degree of infestation and the study (CEC 2000; Gianessi and Carpenter, 1999; and Duffy and Ernst 1999).

There is a reduction in the cost of herbicides for GM production of soybeans and canola. The cost of seed is higher for all GM production products, as expected. Another benefit from GM production reported by producers is increased flexibility in production. For example, it was found that 12% of farmers surveyed cited increased flexibility as a reason for going GM (Duffy et al. 1999, cited in CEC 2000). This increased flexibility may lead to lower costs or increased revenues but these are difficult to quantify.

The impact of any changes in yield and costs on gross margins (assuming no impact on demand and therefore prices) has so far been indeterminate. For GM soybeans, the fall in herbicide costs was reported to be offset by rises in seed costs, with the net returns to land and labour being slightly more for conventional soybeans (Duffy et al. 1999, cited in CEC 2000). This is supported by a United States Department of Agriculture (USDA) study which reported that while there was some positive impact on yield and reductions in herbicide use from GM production, net returns did not change (USDA 2000).

It is more difficult to assess the impact on gross margins for GM corn given that it is highly dependent on the level of insect infestation and thus the potential losses in yield have to be set against the higher price for GM insect resistant seed. A study by Furman Seltz (1998) reported in CEC (2000) shows a gain in returns from using GM corn especially under heavy insect infestation. However, Gianessi and Carpenter (1999) found mixed results from using GM corn, with a gain in returns in 1997 but a loss in 1998, whereas Duffy et al. (1999, cited in CEC 2000) found a small gain. It may be that the use of GM corn reduces the variability of farmers' returns, operating as a kind of crop insurance. The value of this reduced variability is currently unknown but potentially calculable. In the case of canola, results are again mixed with Fulton and Keyowski (1999) reporting lower returns with GM canola, whereas the results from a study in Alberta in 1999 found that GM gave lower returns on one type of soil but a higher returns on another (CEC 2000).

The effects of GM crops on producer surplus are complex, as two articles dealing with this specific issue have shown. In the case of Bt cotton in 1996, US producers did gain and other countries' producers lost producer surplus (Falck-Zepeda et al. 2000). The

authors noted that the pricing strategy Monsanto followed probably affected the division of surplus between the innovator and producers. This *caveat* is important as concentration in the biotechnology industry has increased since 1996. A simple model of world soybean production and trade (Moschini et al. 2000) found that gains by producers were critically dependent on assumptions about yields and the spread of technology. US soybean farmers increased their producer surplus only when the technology did not affect productivity and the technology remained in the US. When yields increased or when other countries adopted the technology, prices decreased and producer returns fell.

This body of literature comprised the most reliable sources available to 2000. Since then, attempts have begun to draw together these findings and make broad conclusions about the relative successes and failures of GM in US agriculture. There have been four key reports which both review the prior material and introduce important new analyses:

- USDA May 2002
- National Center for Food and Agricultural Policy 2002
- UK Soil Association (Warwick & Meziani 2002)
- Commission of European Communities (CEC) Report 2000.

Two of these portray unambiguous findings. The NCFAP ((Gianessi et al.2002) reports significant benefits from GM crops in agriculture. From the results of 40 case studies this report argues that the widespread adoption of GM crops in the US has resulted in significant yield increases, savings for growers and pesticide use reduction. It predicts that successful development of 32 additional biotech cultivars, either not yet fully developed or not yet adopted, will extend similar impacts to other crops. The report predicts economic benefits for every state examined.

The strong claims made by this report regarding the economic performance of GM crops have been viewed with considerable caution after it was revealed that the study was par-financed by Monsanto and the Biotechnology Industry Organisation (BIO).

In contrast, the UK Soil Association (2002) report documents failing markets, dubious on-farm performance and growing broad-based resistance. The report argues that there is major disruption at all levels of the agricultural industry, and estimates a potential cost of $90 million annually through lost sales or lower prices due to crop contamination in both organic and non-GM farms.

With regards to on-farm performance of GM crops, the report finds that:

- Contrary to industry data, GM crops have reduced average farm profitability.
- Herbicide-tolerant soya reduced average returns by about $8.8/acre compared to non-GM soya.
- Bt maize reduced average returns by about $1.3-$3.2/acre compared to non-Bt maize.
- GM seeds are significantly more expensive than non-GM seeds as farmers have to pay a technology fee which adds 25-40% to seed costs and prevents them saving seed.

- A significant fall in herbicide prices has offset the cost of greater use of herbicides for herbicide-tolerant crops.
- GM crops are receiving lower market prices than those available for non-GM crops; guaranteed GM-free crops are obtaining significant price premiums.

This report is cited widely by environmental groups, but the clear positioning of the Soil Association as an opponent to GM has been used to dismiss many of these claims.

Thus, both the NCFAP (Gianessi et al. 2002) and the Soil Association (2002) have had their credibility undermined by close association with key interest groups.

In contrast, the most important reports are those by the USDA and the EU.

The USDA (2000) reported on good progress and performance by GM crops in the US. It reported a positive outlook for GM crops and a range of benefits. In essence, the 2000 report tended towards the positive scenario later outlined by NCFAP (Gianessi et al. 2002).

However, a later USDA report (2002) by the same authors significantly moderated this positive outlook. While they reported positive trends in the uptake of GM crops and environmental performance, they considerably moderated their positive tone in relation to actual on-farm performance of GM crops. In a turnaround that received very wide coverage in the anti-GM media (but almost none in the mainstream US media), the 2002 report suggested that the evidence for beneficial outcomes from GM crops and positive net economic returns for farmers was ambiguous, at best, and that in many cases the evidence clearly demonstrated an absence of benefit. Specific results showed:

- The adoption of herbicide-resistant corn improved farm net returns among specialised corn farms. (However the authors note that the limited acreage on which this crop has been used is likely to be acreage with the greatest comparative advantage for this technology, and that positive financial impacts may also be due to seed companies setting low premiums for herbicide-tolerant corn relative to conventional varieties in an attempt to expand market share.)
- The adoption of herbicide-tolerant soybeans did not have a significant impact on net farm returns.
- The adoption of Bt cotton had a positive impact on net returns amongst cotton farms but adoption of Bt corn had a negative impact on farm returns among specialised corn farms.

In contrast to these on-farm performance evaluations, the USDA (2002) did create a more positive picture about the environmental impacts of GM technologies. USDA (2002) reports on the possible outcomes that occur due to changes in pesticide use and tillage practices – both key concerns for US agriculture. The use of pesticides has declined since the introduction of GM crops in 1996 by 19.1 million-acre treatments or 6.2% of total treatments. Further, whilst there is a reduction in the use of heavy pesticides, other chemicals are used in the treatment of GM crops. For example, glyphosate is substituted for previously used herbicides to treat herbicide-resistant soybeans. Glyphosate is nearly

three times less toxic than previously used herbicides and remains in the environment only half the time (USDA 2002:28). Herbicide tolerant crops also have the potential to facilitate the use of conservation tillage farming practices, as weeds can be controlled without tilling the soil. The benefits of conservation tillage include reduced chances of soil erosion and water and chemical run-off. However, USDA (2002) suggest that while early indications are good for the environmental impacts of GM technologies, there is little definitive empirical evidence thus far, as to what extent GM crops have influenced conservation tillage.

The CEC report on the economics of GM supports the more pessimistic tone of the latter USDA (2002) report, but adds in the poor market performance in Europe of US GM crops. This report gives a European-based perspective on trade issues for GM, with a particular emphasis on the powerful role of public opinion and market gatekeepers. The generally high level of concern among a large majority of Europeans is held to have a "cascading" effect back up the food chain in both domestic and foreign markets (CEC 2000). The GM-Free purchasing actions of the retail industry, such as many supermarket chains in the UK and Europe, are argued to have amplified perceived levels of consumer preference and concern and to have become a powerful shaping force in the market. The report outlines the problems of a bulk commodity trading system, in terms of the segregation, identity preservation and labelling of GM-derived foods.

The European Joint Research Centre report *Review of GMOs Under Research and Development and in the Pipeline in Europe* (2003), also demonstrates the caution in Europe with regard to GM. The authors assert that the 76% decrease in the annual number of GMO field trial notifications can be attributed the EU Council of Environment Minister's decision in 1999 to block any new commercial releases of GMOs, coupled with the general public mistrust of the technology. Furthermore, the survey conducted by the authors demonstrated that the key reasons for cancelling research and development projects within agricultural biotechnology were the unclear legal situation, low consumer acceptance and uncertain future markets.

It is worth noting that the primary difficulties experienced by export sectors deploying GM in the US have been in those sectors providing food crops for human consumption. The success of GM cotton crops is clear-cut in all these reports (although this is perhaps partly the result of the fact that many consumers are not aware that cotton seed oil is used as an industrial food input). Likewise, GM crops being sold into markets for animal feed have experienced different market dynamics to those being sold for human consumption.

3.2 Grower Adoption of GM Crops

The USDA (2002) is more positive about the level of uptake of GM crops across the US. It reports that the estimated global area of GM crops for 2001 is 52.6 million hectares, grown by 5.5 million farmers. The majority of GM crops are grown by four countries: the United States (with 68% of the world total), Argentina (22%), Canada (6%) and China (3%). The amount of GM crops grown in South Africa and Australia in 2001 increased by 33% and 37% respectively. Absolute growth was twice as high in industrial

countries as in developing countries. The main GM crops are in descending order; soybeans (63% of total area of GM crops), corn (19%), cotton (13%) and canola (5%) (James 2002). In the US, the most widely adopted GM crops have been either herbicide-resistant or insect-resistant. The rate of adoption differs depending on the particular crop. By 1997, herbicide-tolerant soybeans comprised 17% of the total soybean acreage in the US, increasing to 56% in 1999 and 68% in 2001. However, in contrast herbicide-tolerant corn has been much slower, remaining at around 8-9% in 1998-2001 (USDA 2002: 4).

An interesting point at issue now is why so many growers have adopted GM crops. One technology promoting organisation argued that "[t]his high adoption rate is a strong vote of confidence in biotech crops, reflecting farmers' need for and satisfaction with the technology" (James, 2001 cited at www.whybiotech.com/index.asp.id=1808). The USDA disagrees, posing the question in its report: "[p]erhaps the biggest issue raised by these results is how to explain the rapid adoption of GM crops when farm financial impacts appear to be mixed or even negative" (USDA 2002: 24). It goes on to answer that the farmers within the analysis commented that they found the new pest control systems easier to use than deploying conventional methods. They considered that the GM crops gave them greater flexibility. This is a useful outcome for farmers but was not the kind of benefit that would show up in the economic analysis of farm performance.

One Iowa State University study suggested an alternative answer: that GM crop uptake can be driven as much by how well farmers *believe* the crops deliver, as it is by factual data on their subsequent performance (Duffy & Ernst 1999). Duffy (2001:7) also comments on pressure from landlords and from advertising in seed planting decisions. The CEC report concurred, arguing that farmers had strong 'profitability expectations' when planting the crops (CEC 2000: 32). This report also noted that farmers had access to promotional material from companies suggesting high yields.

The question now arises as to whether farmers think they can abandon GM varieties if they do not perform. The Canadian case reviewed in the next section seems to indicate that there is a differential response to market difficulties for established GM crops and the potential future market difficulties of as yet unreleased varieties like GM wheat. While this differential response has never been researched, it is possible that extant GM crops are considered a *fait accompli* while choices are still much more open in regard to future GM crops.

3.3 Trade performance of GM crops

Preferences for non-GM crops have affected trade. For example, GM-sensitive European and Asian markets have increased their purchasing of non-GM Brazilian soyabeans and soymeal (Agra Europe 2001). As GM maize production has expanded, EU importers have turned to non-GM countries for their supplies (Agra Europe 2000), and the European Commission (EC) has effectively blocked bulk shipments of US corn to Europe (USDA 2002). USDA figures also show that the amount of US soybeans shipped to Europe fell from 1996 to 2000, as did prices. This was the same period in which US GM production expanded. As noted in a European Joint Research Centre paper (2003:5), the

US is still the main exporter of soybeans to the EU, but import levels have recently decreased and stabilised at 1994 levels after relatively high increases during the 1990s up to 1998. The report says that while there has been a shift from the US and Argentina in soybean imports towards Brazil which might be due to the GM situation, soybean meal imports 'are shared equally between Argentina and Brazil, thus indicating that the GM factor has little or no influence on the purchase decision of this type of commodity'. This market situation, however, is unstable, and could change significantly relative to the uptake of GM animal feed labelling.

An additional problem for trade has been the difference in specific GM crops authorised for production or import. Canada moved quickly into approval of GM canolas for export. This caused a disjuncture with emerging import regimes in different countries. For example, the EU lagged behind Canada in approving specific GM canolas, harming Canada's canola exports to the EU. Similarly, China's rapid introduction of rules on GM food similarly hurt Canada's canola industry (Agra Europe 2001).

The fallout from co-mingling StarLink maize (which was not approved for human consumption) with food-grade maize illustrates what can happen with GM commodities. While Starlink created problems due to an unapproved product entering human consumption chains – thus not relating directly to consumer sentiments regarding genetic modification – the market reactions outlined by Lin et al. (2001-2002) do exemplify trade effects (alongside the more direct and obvious regulatory sanctions against an unapproved product):

- Premiums: StarLink-free maize generally had a premium of 7 to 12 cents per bushel.
- Separation and diversion: By diverting co-mingled maize to approved (non-food) uses, grain handlers moved the appropriate maize to the appropriate market. In the process, they reduced the premium on StarLink-free maize.
- Government involvement: The U.S. and Japanese governments negotiated testing protocols that calmed Japanese buyers and, in turn, US sellers.

An additional trade issue is the intellectual property rights from GM innovations. Several researchers have commented on the importance of property rights for innovators to be able to capture returns to their technologies. Patent protection for biotechnology is not guaranteed internationally and will continue to be an issue in trade negotiations.

3.4 The Economic Analysis of GM in Primary Production in New Zealand

Since the emergence of adverse economic events for GM around 1998-99, a small body of economic analysis has begun to be undertaken in New Zealand around the potential impact of GM. In particular, most of this research comments on the fact that New Zealand has remained one of the few agricultural exporters that did not produce the already available GM crops – thus making New Zealand somewhat unique as a potential GM-free exporter. This literature differs somewhat from the international literature on the economics of GM crops production as New Zealand is not a producer of the key new GM commodities - canola, cotton, soy – and has only a minor corn export sector.

The first analysis to outline these issues was prepared under the auspices of the Independent Biotechnology Advisory Council (IBAC). They issued a discussion paper in 1999: *Economic Implications of a First Release of Genetically Modified Organisms in New Zealand* and solicited comments from the public and various stakeholders. The results of this process strongly informed the Background Briefing Paper: *The Economics of Genetic Modification* prepared by Jan Wright (a member of IBAC) for the Royal Commission on Genetic Modification. This paper clearly showed that there were important issues pertaining to the economic implications of the 'first release' of GM into commercial production in New Zealand, and called for a significant economic debate to be part of the Royal Commission's activities in 2000-2001.

In retrospect, the Royal Commission was characterised by a lack of broad debate on economic issues relating to GM and suffered from a lack of independent advice in the economic area. While a number of economic stakeholders (ranging from Crown Research Institutes, exporters, to anti-GM sectors like the organic agriculture sector) made their case to the Commission, few actually presented economic research in support of their claims. Two exceptions were the Life Sciences Network and the organic agriculture industries.

The Life Sciences Network commissioned Infometrics to provide a series of Computable General Equilibrium (CGE) model runs on a range of scenarios relating to deployment or restriction on GM in the New Zealand economy (Stroombergen 2000). The results were generally positive for GM (although this finding was contested in Nana 2000). As a first attempt at modelling the economic outcomes of GM, the Infometrics work highlighted both the importance of providing robust assumptions under modelling activities, and the need to clearly define and defend the scenarios used to initiate modelling activities. It also highlighted the problematic issue of attempting to compare a future possible sector (GM) with a small minority sector like organic agriculture.

The Royal Commission was also the venue for the first presentation of results from the Lincoln Trade and Environment Model (LTEM) with results being mobilised in presentations by the organic agriculture sector. In a later discussion paper, Saunders and Cagatay (2002) outlined their findings as being generally negative for the adoption of GM in primary production sectors. They also argued that such model runs were preliminary, and needed further elaboration of assumptions and scenarios.

Modelling activities rely on access to solid data on farm production, environmental outcomes, profitability, consumer sentiment, elasticities of demand and consistent data on the future productivity gains that novel farming systems might involve. In the time since the Royal Commission on Genetic Modification, new data has become available to assist in modelling, although there are still important areas of weakness in the data supporting some assumptions.

There have also been some modelling activities in the Australian context, although modelling assumptions used in the Australian research differed significantly from those used in this research. A Productivity Commission Report (Stone et al 2002) applied the

global general equilibrium modelling framework GTAP (Global Trade Analysis Project) to examine potential impacts of GM technology on Australia's trade in 'non-wheat grains' and 'oilseeds'. The results of the three scenarios considered demonstrated that very small 'absolute changes' would occur in Australia's import and export flows. Rather, regions with currently significant GM sectors (such as North America) received the most substantial impacts to trade and income. However, the results did imply that a longer-term expansion of GM technology could influence significant negative impacts on Australia's trade position.

3.5 Export Markets: Trade and Regulatory Strategies

For the demands of different market segments to be relevant, consumers must be able to distinguish between the products they do and do not want. One way for consumers to do this is through product labelling. The concentration of New Zealand exports makes it possible to discuss labelling regimes in its trading partners.

Regulatory strategies address several issues. Firstly, food labelling regulations generally fall into one of two types: mandatory labels on foods produced with GM; and voluntary labels, especially, but not necessarily, on non-GM foods. Secondly, regulations set tolerance levels to indicate the maximum allowable amount of adventitious presence or co-mingling of GM material with non-GM material. Thirdly, the products to be labelled are defined.

The following table sets out the basic labelling regulations in New Zealand's major trading partners:

Country	Mandatory or Voluntary	Tolerance level	Products to be labelled	Notes
Australia	M	1%	Food with novel proteins or DNA	Governed by same rules as NZ
European Union	M	1%	Foods from GMOs GM feed GM additives	Current rules. New more stringent rules are being adopted.
Japan	M	1% - "May contain" 5% - "GM"	Top three ingredients of a product, if greater than 5% of product's weight	
South Korea	M	3%	Top 5 ingredients in a product	
United Kingdom	M	1%	Also requires that restaurant meals with GM foods be labelled	Also under EU rules
United States	V			

Sources: ANZFA (2001); CEC (2000) and Phillips & McNeill, (2000).

It is clear that national governments do not agree over the particulars of labelling. This disagreement has been traced to a fundamental difference in perception of GM (Caswell 2000; Paarlberg 2002). The US and Canada maintain that if GM food is "substantially equivalent" to non-GM, it is therefore subject to the same regulations but nothing additional. However, if the effect of the GM trait is not substantially equivalent, then the product must be labelled. The European Commission, on the other hand, maintains that the "precautionary principle" should prevail, because GMOs are novel organisms and the effects of their introduction into the environment and food system are unknown. This position was adopted after some novel GMOs were approved. Thus the EU has a moratorium on some GMOs but not all. These positions seem to be irreconcilable, but both are defensible and legal under international agreements (Caswell 2000). However, at least one researcher believes that the European Commission position will probably prevail, because importers tend to set international food standards: "[t]he customer is always right, and in world food markets the biggest customers are the Europeans and the Japanese, not the Americans" (Paarlberg 2002: 34).

Within the broader regulatory and trade context, internal gatekeeping effects have emerged due to the actions of some retailers in excluding GM products. The most obvious market where such actions have taken place is the UK, although such actions in the EU and Japan have also been common. Having conducted a review in 1999, *GMfoodnews* conducted a follow-up survey in 2003 and suggested that all the surveyed supermarket chains in the UK were still maintaining a ban on GM ingredients in their own brand products (gmfoodnews.com: 6 Jan 2003). They also noted an increasing trend since 1999 for some supermarkets in the UK to specific GM-free animal feeds.

In the Australasian market Robertson (2002) recorded similar activities as some manufacturers moved to GM-free ingredients to meet the requirements of some supermarkets to avoid the Food Standards Australia New Zealand (FSANZ) GM label on their own-brand products. In both the Australasian and the UK/EU cases, both retailers and some major manufacturers were moving to ensure GM-free product in their brands.[5]

Institutional preferences, retailer strategy and trade barriers are still strongly operating against GM food products in a number of countries. While the industry has been hoping for a quick reduction in these, there is an ongoing dispute between the EU and US over the moratorium on approving new GMOs and the extent and nature of the new regulatory regime for GMOs in the EU.[6]

[5] Thehighest profile manufacturer in New Zealand to go GM free in animal feed is Tegel ('Tegel vows no GM feed for its chooks'. New Zealand Herald, Aug 29 2001).

[6] White House trade advisers have recently advocated against the US pushing ahead with its intended action of taking the EU to the WTO over barriers against GM products (*New York Times* 2003). Such advice was given in the context of a public disagreement between Robert Zoellick (US Trade Representative) and Poul Neilson (EU Development Commissioner) over the legality of EU actions over GM food (*NZ Herald* 2003). This is one possible explanation of why long-promised US action at the WTO is being delayed.

It is arguable that the ongoing difficulties in all three areas – institutional preferences, retailer strategy and trade barriers ─have led to the key political dynamic within North American agriculture evident over the last two years, namely, a broadening of anti-GM sentiment out from the niche groups of environmentalists and organic producers. Instead, opposition to new GM crops in both Canada and Switzerland shows a broad coalition of mainstream agricultural organisations and companies opposed on purely economic grounds to the introduction of new crops. Likewise, some farm groups representing mainstream agriculturalists have begun to mobilise in opposition to GM in agriculture over the last 3 years.

The most intriguing aspect of this dynamic is the difference between farmer politics in commodities where GM crops are already present (corn, canola, soybeans) and in potential new crops (wheat). While activism against GM in the established crops is present, in general, growers are steadily adopting the technology. However, the reception of GM wheat shows a completely different political dynamic. Broad groupings are opposed, including such influential organisations as the Canadian Wheat Board. The key difference appears to be that farm groups and industry organisations consider that once GM is released in a sector, it is a *fait accompli*, and the chances of successful segregation or reversion to non-GM are small. In contrast, in sectors where GM is not present, hard questions are being asked as to the economic merits of the technology.

4. Country Case Studies: Switzerland and Canada

It is interesting to note whether other countries that trade on an environmental image have also raised questions about the uses of GM technologies. The two key comparisons are Switzerland and Canada. The consumer and in-bound tourism surveys reported elsewhere in this report clearly showed that New Zealand, Canada and Switzerland trade to some extent on a positive environmental image. This section reviews the current state of policy and concerns about market image in the light of biotechnologies (including GM).

4.1 Switzerland

A comprehensive review of Swiss biotechnology developments is provided by Bonfadelli et al. (2001). The Swiss government has been faced with conflict between two important political constituencies. In general, the Swiss public have been described as strongly anti-GM. However, there is also a substantial Swiss biotechnology industry. The Swiss government's attempts to regulate a path between the two has involved two initiatives: the Gen-Shutz and the Gene Lex initiative:

- In 1993 a Swiss 'popular initiative' - the Gen-Shutz Initiative (GSI) - was submitted for parliamentary debate. The initiative called for the prohibition of
    1. the production and sales of GM animals;
    2. the release of GM plants and animals, and
    3. the issuing of patents on GM plants and animals.

- By 1997 the Swiss parliament had developed an indirect counterproposal to the GSI with a specific gene law. Similarly Swiss industrialists decided to follow the strategy of not directly opposing the GSI, but rather pushing for additional legislation. In March 1997 the first draft of the proposed Gene Law was issued by the Swiss government, specifically addressing the regulation of gene technology. In addition they took some time to develop the 'Gene Lex package' which involved modifications to various other laws, mainly within environmental legislation, but also those concerning areas such as agriculture.
- In April 1998, a unique event occurred when several hundred genetics researchers and sympathisers gathered to march in demonstration against the GSI.
- The vote on the GSI was eventually rejected by a majority of Swiss voters (66.6%).
- In January 2000 new drafts of the Gene Law and the Gene Lex Package were published for further debate. The Gene Lex package was supported by most organisations, including the pharmaceutical industry and farmers, but criticised by some branches of the agricultural industry and by environmental organisations (Bonfadelli et al. 2001).

In October 2002, after lengthy debate, parliamentary representatives narrowly rejected the proposed five-year moratorium. However, they approved fairly strict regulations on the planting and labelling of GMOs. The debate was the subject of intense lobbying, from both environmental groups on one side and agrochemical companies such as Syngenta on the other (Reuters News Service 2002).

There has been some reporting of political debates inside Switzerland as to whether GM is compatible with their natural image. In 1999, Switzerland's federal environmental office (BUWAL) turned down a request to trial T25 maize, citing health and environmental concerns. The BUWAL statement said the ruling also sought to protect the image of Swiss products: "Swiss agriculture lives on our products' reputation for being pure and close to nature. Such gene technology experiments affect this image. This can have a far reaching impact on our agricultural sector" (cited in ProMED Mail Communication 1999). The statement also referred to the position of 'Switzerland as a unique GM-free island within Europe'.

In October 2002, however, the Swiss parliament voted not to impose a moratorium on GM testing. In response, a coalition of Swiss farmers and retailers announced a voluntary boycott on producing and selling genetically modified food. The Swiss companies/organizations declared they would not use GMOs now or at any time in the future, and would do all they could to maintain the GM-free status of the whole production chain, including the providers of their raw materials. The group included the Swiss Farmers Organisation (90% of Swiss farmers), Organic Farmers Organization (10% of farmers), Swiss Milk Producers (100%), Swiss Bakers Federation, Migros, Coop (retailers controlling 70% of the market) and Carrefour (Swiss Info Organic Newsline 2002). Additional to the boycott, the Swiss farmers' union announced an initiative of marketing food with a 'Made in Switzerland, without GMO' label (Thuburn 2002).

Currently, the Swiss government is trying to make space for this initiative to occur without disabling the activities of the large Swiss-based biotechnology companies. Their solution is the proposed Gene Lex package and many parties are watching closely to see whether the Swiss can form the Gene Lex package into a workable regulatory framework.

4.2 Canada

Canada also trades on an environmental image – but unlike Switzerland is strongly centred in bulk commodity trading. Media reporting suggests that there has been some widespread discontent in those sectors (corn, canola) where European bans have hurt export returns.

The Canadian government has played a pro-active role in the development and promotion of biotechnology:

- The Canadian government identified biotechnology as a strategic technology in 1980 and announced a National Biotechnology Strategy in 1983. The focus of the strategy was on promoting biotechnology research in a few targeted areas including agriculture, forestry, aquaculture and pharmaceuticals (Einsiedel & Medlock 2001). The Canadian Biotechnology Strategy (CBS) vision is: "to enhance the quality of life of Canadians in terms of health, safety, the environment and social and economic development by positioning Canada as a responsible world leader in biotechnology" (CBS 1998: 8).
- The Canadian regulatory system for products of biotechnology is based on the assessment of 'novel traits', in a product rather than process-based philosophy. Canada has chosen to amend existing legislation and regulatory departments to accommodate these new products (Flint et al. 2000).
- Seven ministries share responsibilities in biotechnology regulation: Agriculture, Health, Environment, Fisheries, Mining, Industry and Foreign Affairs and Trade.
- For products of food biotechnology, the Food and Drugs Act was supplemented by the Novel Foods Regulations in 1999 (Einsiedel & Medlock 2001).

Canadian agriculture is highly dependent on world markets, with 70% of the country's total agricultural production being exported. Value-added or new crops have been held to play an important role in meeting Canada's domestic and international agricultural needs. Such products have been approved and trialed in Canada at a rapid rate, second only to the US. Approved biotechnology crops in Canada are sugar beet, argentine canola, polish canola, squash, soybeans, cotton, tomato, potato and corn (Einsiedel & Medlock 2001). However, canola is the main commercial GM crop, grown predominantly on the prairies. Approximately 60% of the canola there is genetically modified. Maize and soya are primarily grown in Ontario. In 2001, the total area of transgenic crops in Canada was estimated at 3.2 million hectares (Warrick and Meziani 2002).

Canada has a strong environmental image. However, the relationship between this image and commodity trading are not clear – especially the experience of GM commodity exports from Canada which, have suffered significant declines in export volumes to Europe due to moratoria on some GM products. Currently, Canadian farmers grow GM

canola, soybeans and corn, including varieties which are not approved by the EU. There is an effective ban on canola due to the problems of the bulk-handling system, where GM and non-GM canola are mixed together. The proposed European rule of 0.5% GM thresholds for unauthorised grain have Canadian exporters concerned that guaranteeing non-GM shipments to Europe will be virtually impossible (Rampton 2002).

EU moratoria and regulations on GM also hold implications for the debate over whether GM wheat should be commercialised in Canada. Canadian food exporters and the wider public have voiced great concern over the potential introduction of GM wheat into Canada. The extent of this concern was demonstrated in July 2001,when an unprecedented coalition of 210 major agricultural, environmental and citizens groups in Canada (including the Canadian Wheat Board and the National Farmer's Union) wrote to Prime Minister Jean Chretien asking: "[that] you act immediately to prevent the introduction of GM wheat into Canadian food and fields unless the concerns of Canadian farmers, industry, and consumers are addressed adequately" (cited in Phillipson 2001).

Perhaps the most revealing participant in this anti-GM wheat coalition is the Canadian Wheat Board (CWB). The CWB is solely responsible for the sale and marketing of Western Canadian wheat and barley and is one of the world's largest grain marketing companies. Of particular concern to the CWB was the potential loss of major export markets if the conventionally grown Canadian wheat supply became contaminated by GM wheat (Phillipson 2001).

Within this debate, Canadian producers have repeatedly cited the case of Australia stealing Canadian markets – something Australian farmers also seem to be aware of. A canola farmer from Victoria argued that Australia's 'clean green image' in regard to GM gave an advantage over many competitors and has even helped gain markets in the European Union that were previously supplied by Canada (Jackson 2002).

4.3 Summary

The case study countries show that for Switzerland, the compatibility between GM and an environmental image is an ongoing political issue for local producers and companies. The government has not yet provided a solution in either Canada or Switzerland. For Canada, even as a commodity trader, the major coalition against GM wheat is important. However, this coalition is based more on direct market access crises rather than impacts on Canada's environmental image.

In both cases, there has been a major transition over the last 18 months from opposition to GM being centred in the organic agriculture (and environmental groups) sector to a more broad-based concern (on purely economic grounds) from other producers, companies and producer boards.

5. Discussion

The effect of an adoption of GM in agriculture on New Zealand's CGI is tied up in the larger issue of the economic performance of GM agriculture generally. There are three areas of critical interest in the economic performance of GM in agriculture and food:

- market demand reflecting consumer sentiment towards the products;
- institutional preference, retailer strategy, trade barriers and the politics of market protection against GM; and
- on-farm evaluations of GM applications outlining tangible benefits or productivity gains.

While the results vary for different types of GM, the overall picture is sobering for the use of GM in food crops, while considerably more positive for GM in pharmaceutical and other medical uses.

In the current circumstances, market demand still remains poor for food derived from GMOs; with most GM products experiencing lower demand than their non-GM counterparts. One exception for agricultural producers is cotton – a non-food product. Similarly, medical products derived from GM ingredients or processes are not subject to the same broad negative market sentiments.

Finally, while the two previous factors – market demand and access issues – have been constant since 2000, the third issue – actual economic performance of GM crops in US agriculture – is only now becoming clear. Data from more years, more crops, and more regions has become available. While GM cotton remains positive, corn and soybean production has been re-evaluated by the USDA since 2000, and this evaluation suggests that these crops have actually under-performed on the farm.

While these conclusions can be drawn from the available literature, this review has served to indicate where there is very little knowledge about GM products, consumers and markets. The following section outlines these key issues which remain unresolved or cannot be informed by existing data.

5.1. Issues Outstanding

Clearly, there are no final answers as to the extent and nature of the risks and opportunities presented by GM in commercial production. There are, however, much clearer indications in the prior literature as to what the key issues are:

• To what extent is New Zealand's trade image influenced by consumer perceptions of New Zealand as having a good environmental image?

• What share of our overseas market might be influenced by shifts in this environmental image?

• What is the strength of the association between GM and broader environmental image in New Zealand?

• Does New Zealand export to consumers who hold a generic vision of New Zealand as a 'clean green' country, no matter what products they are purchasing?

• How will consumer sentiment be influenced by the presence of commercial GM activities in New Zealand even if such activities are not directly related to the kinds of products from New Zealand that are being purchased?

• What is the possible consumer reaction to non-GM animal products in which the animals were fed GM animal feed?

• What are the risks and opportunities presented to mainstream New Zealand agriculture (rather than to the small organic sector) by GM?

• What are the economic risks and opportunities of deploying GM technologies in environmental remediation?

• What are the risks and opportunities of deploying GM technologies in medicine?

• If New Zealand experiences adverse market effects from adopting GM products, what level of productivity gains would be required to ensure profitability for GM products?

• How likely is it that consumer purchasing behaviour will be influenced by price changes?

• Given that current consumer sentiment is negative for some segments of our markets, what are the characteristics of these segments (especially purchasing power)?

• What is the degree to which stated consumer preferences are actually expressed in purchasing behaviour?

• What is the likely duration of negative consumer sentiment in some market segments?

• What is the likely duration of institutional lock-out of GM products in markets by the likes of supermarket chains?

• What is the GM-free premium that markets are prepared to sustain in the long term?

• What is the likely lead-time in the development of novel GM products that will have strong commercial relevance to New Zealand?

6. Bibliography

Agra Europe. (2000). *Brazil joins the maize export club*. pM/9. 22 December 2000.

Agra Europe. (2001). *Brazilian soya exports still rising*. Agra Europe, pM/2. 9 November 2001

Australia New Zealand Food Authority. 2001. *Genetically Modified Foods* (Brochure). Revised Nov 2001, downloaded 29 Apr 2002. www.anzfa.gov.au.

Bell, C. (1996). *Inventing New Zealand: Everyday Myths of Pakeha Identity*. Auckland: Penguin Books.

Bonfadelli, H., U. Dahinden., M. Leonarz,, M. Schanne, M., C. Schneider, C and S. Knickenberg, S. (2001). Biotechnology in Switzerland: from street demonstrations to regulations. In G. Gaskell and M. W. Bauer (eds.) *Biotechnology 1996-2000: The Years of Controversy*. London, Science Museum: 282-291.

Bredahl, L. (2001). Determinants of Consumer Attitudes and Purchase Intentions with Regard to Genetically Modified Foods - Results of a Cross-National Survey. *Journal of Consumer Policy*, 24: 23-61.

Bredahl, L, K. Grunert, and L. Frewer. (1998). Consumer Attitudes and Decision-Making with Regard to Genetically Engineered Food Products - A Review of the Literature and a Presentation of Models for Future Research. *Journal of Consumer Policy*, 21: 251-277.

Burton, M., D. Rigby, T. Young, and S. James. (2001). Consumer Attitudes to Genetically Modified Organisms in Food in the UK. *European Review of Agricultural Economics*, 28 (4): 479-498.

Campbell, H., R. Fitzgerald, C. Saunders, and L. Sivak. (2000). *Strategic Issues for GMOs in Primary Production: Key Economic Drivers and Emerging Issues*. CSAFE Discussion Paper #1. Dunedin, New Zealand: Centre for the Study of Agriculture, Food and Environment, University of Otago.

Caswell, J. (2000). Labelling Policy for GMOs: To Each His Own? *AgBioForum*, 3 (1).

CBS. (1998). The 1998 Canadian Biotechnology Strategy: An Ongoing Renewal Process. Ottawa: Industry Canada.

CEC. (2000). *Economic Impacts of Genetically Modified Crops on the Agri-Food Sector*. Commission of the European Communities. Available from http:// europa.eu.int/comm/agriculture/public/gmo/fullrep/index.htm

Cook, A. (2000). *Attitudes and Intentions Towards Purchasing Food Produced Using Genetic Engineering: modelling and understanding the motivations for purchasing behaviour*. Unpublished M.Appl.Sci Thesis, Lincoln University.

Cook, A., J. Fairweather and H. Campbell. (2000). *New Zealand Farmer and Grower Intentions to Use Genetic Engineering Technology and Organic Production Methods*. AERU Research Report No. 243, September 2000. Lincoln University: Canterbury.

Cook, A., K. Hughey, G. Kerr, and R. Cullen. (2001). *Quality of the Environment.* Paper presented to the New Zealand Society of Agricultural Economists. Blenheim.

Council for Biotechnology Information. (2002). *Biotech acres: Global biotech plantings show double-digitiIncrease for sixth straight ear.* Available from www.whybiotech.com/index.asp.id=1808

Duffy, M. and Ernst M. (1999). Does planting GMO seed boost farmers' profits? *Leopold Letter*, 11(3).

Einsiedel, E. F. and J. E. Medlock (2001). Canada on the gene trail. *Biotechnology 1996-2000: The Years of Controversy*. In G. Gaskell and M. W. Bauer (eds.) London, Science Museum:145-156.

Joint Research Centre. (2003). *Review of GMOs under research and development and in the pipeline in Europe.* Joint Research Centre, European Commission. Available from http://www.jrc.es/gmoreview.pdf

Falck-Zepeda, J., G. Traxler, and R.G. Nelson. (2000). Surplus distribution from the introduction of a biotechnology innovation. *American Journal of Agricultural Economics* 82 (2): 360-369.

Flint, J., L. Gil, J. Verastegui, C. Irarrazabal, and J. Dellacha. (2000). Biosafety information management systems. A comparative analysis of the regulatory systems in Canada, Argentina and Chile. *Electronic Journal of Biotechnology* (online) Available from http://www.ejb.org/content/vol3/issue1/full/2/bip/

Frewer, L., C. Howard and J. Aaron. (1998). Consumer Acceptance of Transgenic Crops. *Pesticide Science*, 52: 388-393.

Frewer, L., C. Howard and R. Shepherd. (1995). Genetic engineering and food: What determines consumer acceptance? *British Food Journal*, 97(8):31-36.

Frewer, L., C. Howard and R. Shepherd. (1996). The Influence of Realistic Product Exposure on Attitudes Towards Genetic Engineering of Food. *Food Quality and Preference*, 7(1):61-67.

Frewer, L., R. Shepherd and P. Sparks. (1994a). Biotechnology and Food Production: Knowledge and Perceived Risk. *British Food Journal*, 96(9): 26-32.

Frewer, L., R. Shepherd and P. Sparks. (1994b). The Interrelationship Between Perceived Knowledge, Control and Risk Association with a Range of Food-Related Hazards Targeted at Self, Other People and Society. *Journal of Food Safety*, 14: 19-40.

Frewer, L., C. Howard, D. Hedderley and R. Shepherd. (1999). Reactions to Information about Genetic Engineering: impact of source characteristics, perceived personal relevance, and persuasiveness. *Public Understanding of Science*, 8(1):35-50.

Fulton, M. and Keyowski, L. (1999). The Producer Benefits of Herbicide-Resistant Canola. *Ag Bio Forum*, 2 (2) Spring 1999.

Gamble, J., S. Muggleston, D. Hedderly, T. Parminter and N. Richardson-Harman. (2000). *Genetic Engineering – the public's point of view.* Mount Albert Research Centre. Horticulture and Food Research Institute of New Zealand Limited.

Gamble, J and A. Gunson. (2002). *The New Zealand Public's Attitudes Regarding GM Food: May and October 2001 –Full Report.* Auckland: HortResearch.

Gendall, P. J. Hosie and D. Russell. (1993). *New Zealanders' Attitudes to the Environment*. International Social Survey Programme. Dept of Marketing:Massey University.

Gianessi, L. P. and J. E. Carpenter. (1999). *Agricultural Biotechnology: Insect Control Benefits.* Washington DC: National Center for Food and Agricultural Policy.

Grunert, K, T. Bech-Larsen, L. Lahteenmaki, O. Ueland, A. Astrom. (2002). *Attitudes Towards the Use of GMOs in Food Production and Willingness to Buy Cheese Produced Using GMOs for Respondents with and Without Tasting Experience'* Paper presented at the 6th International Consortium on Agricultural Biotechnology Research Conference, Ravello, Italy.

GM Food News. (2003). *UK Supermarkets maintain strict GM free policy for 2003*. Press release 6 January 2003. Available from http://www.connectotel.com/gmfood/gm060103.html

Hoban, T.J. (1989). Sociology and Biotechnology: Challenges and Opportunities. *Southern Rural Sociology*, 6:46-63.

Hoban, T.J. (1994). *Consumer Awareness and Acceptance of Bovine Somatotropin (BST),* Washington DC: Grocery Manufacturers of America, pp.1-15.

Hoban, T.J. (1995). The Construction of Food Biotechnology as a Social Issue. In, D. Maurer and J. Sobal (eds.), *Eating Agendas: Food and Nutrition as Social Problems*, pp.189-209. New York:Aldine de Grutyer.

Hoban, T.J. (1996). 'How Japanese consumers view biotechnology.' *Food Technology*, 50 (7):85-88.

Hoban, T.J. (1997). Consumer Acceptance of Biotechnology: An International Perspective. *Nature Biotechnology*, 15: 232-234.

Hoban, T.J. (1999a) Consumer Acceptance of Biotechnology in the United States and Japan. *Food Technology*, 53(5): 50-53. Available from http://www4.ncsu.edu/~hobantj/Jap-US.htm

Hoban, T.J. (1999b). Public Perceptions and Understanding of Agricultural Biotechnology. International Information Programs, U.S. Department of State, *Economic Perspectives*, 4(4), October 1999. Available from http://usinfo.state.gov/journals/ites/1099/ijee/bio-hoban.htm

Hoban, T.J. (2000). *Consumer and Food Industry Perspective on Food Biotechnology*, May 2000. Available from http://www.biotech-info.net/consumer_perspective.html

Huffman, W., J. Shogren, M. Rousu, and A. Tegene. (2001). *The Value to Consumers of GM Food Labels in a Market with Asymmetric Information: Evidence from Experimental Auctions.* Paper presented at the Annual Meeting of the American Agricultural Economics Association, Chicago, Illinois.

Hughey, K., G. Kerr, R. Cullen and G. Maclean. (2002). *Public Perceptions of New Zealand's State of the Environment-how 'clean' and how 'green'?* Author's Copy.

IFIC (no date). *US Consumer Attitudes Toward Food Biotechnology*. International Food Information Council (IFIC). Available from http://ific.org/proactive/newsroom/release.vtml?id=18001&PROACTIVE_ID=cecfcf

Independent Biotechnology Advisory Council. (1999). *Economic Implications of a First Release of Genetically Modified Organisms in New Zealand.* Wellington: IBAC.

Jackson, Monica. (2002). Victorian farmers want delay on release of GM crops. *Herald and Weekly Times*, 11 September 2002. Accessed from CropChoice News www.non-GM-farmers.com/news_details.asp?ID=15

James, S. and M. Burton. (2002). Consumer Attitudes to GM Foods: Some Preliminary Results from Western Australia. In Fraser, R. and J. Taylor (eds.) *Research Profile: Agricultural and Resource Economics at the University of Western Australia in 2001*. Perth:University of Western Australia.

Kamaldeen, S. and D. Powell. (2000). *Public Perceptions of Biotechnology Food Safety Network Technical Report #17.* University of Guelph: Department of Plant Agriculture. Available from http://www.plant.uoguelph.ca/safefood/gmo/public-perceptions-biotech-augoo.htm#conclusion

Kiesel, K., D. Buschena, and V. Smith. (2002). *Consumer Acceptance and Labelling of GMOs in Food Products: A Study of Fluid Milk Demand*. Paper presented at the 6th International Consortium on Agricultural Biotechnology Research Conference, Ravello, Italy.

Lin, W, G. K. Price, and E. Allen. (Winter 2001-2002). 'StarLink™: Where No Cry9C Corn Should Have Gone Before. *Choices*, pp. 31-34.

Macer, D. (1992). *Attitudes to Genetic Engineering: Japanese and International Comparisons*' Christchurch:Eubios Ethics Institute.

Macer, D. (1994). *Bioethics for the people by the people.* Christchurch:Eubios Ethics Institute.

Macer, D. (1998). *Public Perceptions of Biotechnology in New Zealand and the International Community: Eurobarometer 46.1.* Christchurch: Eubios Ethics Institute.

Moon, W. & S. Balasubramanian. (2001). Public Perceptions and Willingness-To-Pay a Premium for Non-GM Foods in the US and UK.' *AgBioForum*, 4 (3&4). Available from http://www.agbioforum.org.

Moschini, G., H. Lapan, and A. Sobolevsky. (2000). Roundup Ready Soybeans and Welfare Effects in the Soybean Complex. *Agribusiness* 16 (1): 33-55.

Nana, G. (2000). *Review of economic wellbeing of biotechnology impacts*. Royal Commission for Genetic Modification submission of Wendy McGuinness.

Gianessi, L., C. Silvers, S. Sankula, S. and J. Carpenter.. (2002). *Plant Biotechnology: Current and potential impact for improving pest management in US Agriculture. An analysis of 40 case studies*. Washington DC:National Center for Food and Agricultural Policy.

New York Times. (2003). US Delays suing Europe. February 5.

New Zealand Herald. (2003). EU's Neilson blasts US 'lies' in GM food row. January 21.

Norton, J. (1998). Throwing up Concerns About Novel Foods. In R. Hindmarsh, G. Lawrence, J. Norton (eds*.), Altered Genes – Reconstructing Nature: The Debate*, pp.173-185. Sydney: Allen and Unwin.

Noussair, C., S. Robin and B. Ruffieux. (2002). Do consumers not care about biotech foods or do they just not read the labels? *Economics Letters* 75(1):47-54.

OECD Committee for Agriculture. (2000). http://www.olis.oecd.org/olis/2000doc.nsf/LinkTo/agr-ca-apm(2000)5-final.

PA Consulting Group. (2001). *Valuing New Zealand's Clean Green Image*. Report prepared by S. Thornton, S. Paul and G. Kerr. Wellington: PA Consulting Group.

Paarlberg, R.. (28 June 2002). *The Contested Governance of GM Foods: Implications for U.S.-EU Trade and the Developing World*. Massachusetts: Wellesley College.

Marris, C., B. Wynne, P. Simmons, and S. Weldon. (2001). *Public Perceptions of Agricultural Biotechnologies in Europe.* Commission of European Committees: 113.

Phillips, P. and H. McNeill. (2000). A Survey of National Labelling Policies for GM Foods. *AgBioForum*, 3 (4): 219-224. Available from http://www.agbiogforum.org

Phillipson, M. (2001). Agricultural Law: containing the GM revolution. *Biotechnology and Development Monitor*, 48:2-5.

ProMED-mail (1999) Genetically Modified Plants, Planting Banned – Switzerland. Available from www.agnic.org/pmp/1999/gmp0502.html

Rampton, R. (2002). *New GM thresholds in EU worry Canadian exporters'* Planet Ark. Available from www.planetark.org/avantgo/dailynewsstory.cfm?newsid=18847

Reuters News Service. (2002). *Swiss Activists still seek ban on GMO testing.* Planet Ark. Available from www.planetark.org/dailynewsstory.cfm/newsid/18072/newsDate/7-Oct-2002/story.htm

Robertson, D. (2002). Marking Time: Australian Rules on Genetically Modified Food Labels Aren't As Tough As They're Made Out To Be. *Far Eastern Economic Review,* 165(5): 41.

Saunders, C. and Cagatay, S. (2001). *Economic Analysis of Issues Surrounding Commercial Release of GM Food Products in New Zealand.* Commerce Division Discussion Paper No. 94. Canterbury:Lincoln University.

Sheehy, H., M. Legault, and D. Ireland. (1998). Consumers and Biotechnology: A Synopsis of Survey and Focus Group Research. *Journal of Consumer Policy*, 21:359-386.

Siegrist, M. (1998). Belief in Gene Technology: The Influence of Environmental Attitudes and Gender. *Personality and Individual Differences* 24 (6):861-866.

Small, B. H., J. A. Wilson, and T. G. Parminter. (2002). *Clean, Green and Healthy? Genetically Engineered Food: A Perceived Threat to New Zealand's Brand Image*. Hamilton, New Zealand: AgResearch.

Small, B. H., J. A. Wilson, J. A. Pedersen, and T. G. Parminter. (2001). *Genetic Engineering and the Public: Attitudes, Beliefs, Ethics and Cows.* Hamilton, New Zealand: AgResearch.

Stone, S., and Matysek, A. and Dolling, A. (2002). *Modelling Possible Impacts of GM Crops on Australian Trade.* Melbourne: Productivity Commission Staff Research Paper.

Stroombergen, A. (2000). *Witness Brief for the New Zealand Life Sciences Network (Inc*). Wellington: Royal Commission on Genetic Modification.

Swiss Info Organic Newsline (2002) 'Switzerland: GM-Free Food.' *Swiss Info Organic Newsline* 3(39). Available from www.worldwholefoods.com/news.cfm?action=article&nid=4773DC42-1940-46D8-AA78BB1E24809A2.

Thuburn, D. (2002). *Consumer, Environmental Groups Stage Protest Against GMOs*. World Markets Research Centre Daily. Available from http://131.104.232.9/agnet/2002/10-2002/agnet_october_17-2.htm

United States Department of Agriculture (USDA). (2002). *Adoption of Bioengineered Crops*. Agricultural Economic Report No. 810.

United States Department of Agriculture (USDA). (2000). *Genetically Engineered Crops for Pest Management in U.S. Agriculture: Farm Level Effects*. Agricultural Economic Report No. 786.

Warwick H. and G. Meziani, G. (2002*). Seeds of Doubt: North American farmers' experiences of GM crops*. Bristol: United Kingdom Soil Association.

Woodward Clyde. (1999). *Key Opportunities and Risks to New Zealand's Export Trade from Green Market Signals.* Report to the Ministry for the Environment. Wellington: Woodward Clyde.

Wright, Jan. (2000). Background Briefing Paper: *The Economics of Genetic Modification.* Wellington: Royal Commission on Genetic Modification.

Zechendorf, B. (1994). What the Public Thinks About Biotechnology: Better than Synthetic Food but Worse than Organ Transplantation: A Survey of Opinion Polls. *Bio/Technology*, 12(9): 870-875.

Articles and Polls Relating to Public Perceptions of Biotechnology

Aerni, P. (2001). *Public Attitudes towards Agricultural Biotechnology in Developing Countries: A Comparison between Mexico and the Philippines*. Cambridge, Center for International Development. 2002: 47.

Aerni, P. (2002). *Public Attitudes Towards Agricultural Biotechnology in South Africa*. Cambridge, Harvard University. 2002: 37.

Board, N. S. (2000). Science and Technology: Public Attitudes and Public Understanding. *Science and Engineering Indicators - 2000*. Arlington, National Science Foundation.

Directorate-General for Press and Communication, P. O. S. (2001). *Eurobarometer 55.2: Europeans, science and technology*. Brussels, European Commission: 62.

Einsiedel, E. F. (2000). Cloning and its discontents- a Canadian perspective. *Nature Biotechnology* 18:945-947.

Gaskell, G. and M. W. Bauer, Eds. (2001). *Biotechnology 1996-2000: The years of controversy*. London, Science Museum.

IFIC (no date). *US Consumer Attitudes Toward Food Biotechnology*. International Food Information Council (IFIC). Available from http://ific.org/proactive/newsroom/release.vtml?id=18001&PROACTIVE_ID=cecfcf

Macer, D., & Cen Ng, M. (2000). Changing attitudes to biotechnology in Japan. *Nature Biotechnology* 18: 945-947.

Mackay, S., Nicolson, R., Brinsdon, S. (2000). *Public Views on the Biotechnology Question*. Christchurch, Independent Biotechnology Advisory Council (IBAC).

Marris, C., Wynne, B., Simmons, P., Weldon, S. (2001). *Public Perceptions of Agricultural Biotechnologies in Europe*. Commission of European Committees: 113.

MORI-Polls (1998). *Public Attitudes Towards Genetic Engineering.* MORI-Polls. 2002.

MORI-Polls (1999). *Public Won't Swallow GM Contamination of Organic Crops.* MORI polls. 2002.

MORI-Polls (1999). *Genetically Modified Food On Scottish Election Agenda*. MORI-Polls. 2002.

MORI-Polls (2002). *Public Uncertainty over Environmental Issues.* MORI-Polls. 2002.

Priest, S. H. (2000). US public opinion divided over biotechnology? *Nature Biotechnology* 18: 939-942.

Shanahan, J., D. Scheufele et al. (2001). The Polls-Trends: Attitudes about agricultural biotechnology and genetically modified organisms. *Public Opinion Quarterly* 65: 267-281.

Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 2
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

The effect of GMO release on market perceptions of the NZ environment
Questionnaire (phone version layout)

November 2002

The Effect Of GMO Release On Market Perceptions of the NZ Environment

Questionnaire (Phone Version Layout)

"Good morning/afternoon/evening. I am Xxx, from NRB, the market and social research firm. Is there a man/woman aged 18 years or over living in your home?" (IF MORE THAN ONE, ASK FOR THE ONE WHO LAST HAD A BIRTHDAY. IF OUT, ASK FOR SUITABLE CALLBACK TIME)

A. ***Introduction***

"We would like to get your impression of the state of the environment in a number of countries. It's only your personal image of the country we are after, so you don't need to have studied or visited the countries."

B. ***Definition of Environment*** [READ EACH POINT TO THE RESPONDENT]

"By "state of the environment" we mean how well the country manages to…

- "minimize pollution of their air, rivers and seashore",
- "minimize erosion or chemical damage to the land",
- "protect natural plants and animals, including large reserves",
- "keep towns and cities clean, with many trees and parks".

In short, people's use of the environment is managed to be sustainable, clean and green."

C. ***Questions on relative image of the environment***

Q.1 "I'll read out the names of some countries. Would you please answer by saying whether your image of their environment was…

very good, among the best,
OR
just good, above the average,
OR
average, say in the middle,
OR
not very good, below the average,
OR
relatively bad, among the worst.

Of course, if no image comes to your mind at all, just say "no image"."

[READ OUT EACH COUNTRY, STARTING AT THE ASTERISK. THEN READ THE SCALE.

REFRESH THE PERSON ON THE DEFINITION, OR THE SCALE, AS SUITS THEIR INDIVIDUAL GRASP OF WHAT IS REQUIRED OF THEM.]

	"Very good - among the best"	"Good - above average"	"Average"	"Not good - below average"	" Bad - among the worst"	No Image
Mexico	5	4	3	2	1	9
Switzerland	5	4	3	2	1	9
Thailand	5	4	3	2	1	9
New Zealand	5	4	3	2	1	9
Argentina	5	4	3	2	1	9
Australia	5	4	3	2	1	9
South Africa	5	4	3	2	1	9
Canada	5	4	3	2	1	9
Netherlands	5	4	3	2	1	9
China	5	4	3	2	1	9
United States	5	4	3	2	1	9
United Kingdom	5	4	3	2	1	9
Japan	5	4	3	2	1	9

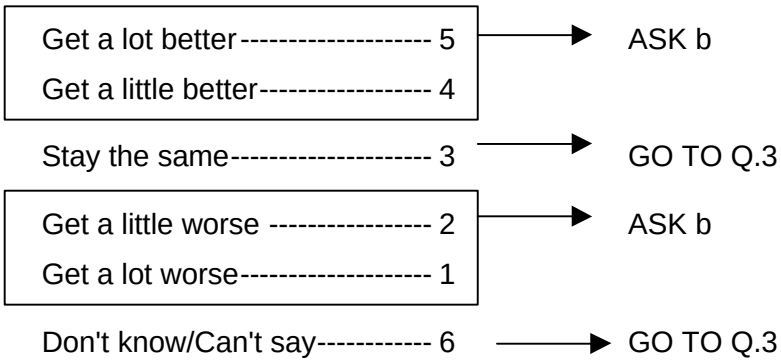
D. ***Questions on Image Change***

"This next question refers to your image of the state of the environment in **New Zealand**."

[IF NZ WAS ANSWERED "NO IMAGE" IN THE PREVIOUS SECTION, SAY "You said earlier you had no image of NZ's environment so please answer the next question on the basis that it is "average - neither good nor bad".]

Q.2 "Suppose New Zealand was one of two or three countries that used genetic technology to control local pests such as rats or wasps. For example, a gene which caused them to breed less often was put into a number of rats or wasps. These are then released to mix with those in the wild so that the gene is passed around."

(a) Would your image of that country's environment get better, stay the same, or get worse? IF BETTER/WORSE, ASK: "By a lot or a little?""



(b) "Can you say why?" (RECORD FULLY)

_____

_____

_____

Q.3 "Suppose New Zealand was one of two or three countries to use a strain of rye grass modified by genetic technology. The gene of the grass would be changed to increase its food value. Farmers would plant fields of the modified rye grass to feed their livestock."

(a) Would your image of that country's environment get better, stay the same, or get worse? IF BETTER/WORSE, ASK: "By a lot or a little?""

Get a lot better---------- 5 → ASK b
Get a little better---------- 4

Stay the same---------- 3 → GO TO Q.4

Get a little worse ---------- 2 → ASK b
Get a lot worse---------- 1

Don't know/Can't say---------- 6 → GO TO Q.4

(b) "Can you say why?" (RECORD FULLY)

_____

_____

_____

Q.4 "Suppose New Zealand was one of two or three countries to use a virus whose genes have been changed in such a way that protects a person against a contagious disease such as Hepatitis or Meningitis. The modified virus, once in the person's bloodstream, would remain there, attacking the disease virus if or when the person got infected."

(a) Would your image of that country's environment get better, stay the same, or get worse? IF BETTER/WORSE, ASK: "By a lot or a little?"

Get a lot better---------- 5 → ASK b
Get a little better---------- 4

Stay the same---------- 3 → GO TO Q.5

Get a little worse ---------- 2 → ASK b
Get a lot worse---------- 1

Don't know/Can't say---------- 6 → GO TO Q.5

(b) "Can you say why?" (RECORD FULLY)

_____

_____

_____

Q.5 "Suppose New Zealand was one of two or three countries **not to use** genetically modified organisms in production, **nor** release GM organisms into the environment."

(a) "Would your image of that country's environment get better, stay the same or get worse? IF BETTER/WORSE, ASK: "By a lot or a little?""

Get a lot better ---------- 5	→ ASK b
Get a little better ---------- 4	
Stay the same ---------- 3	→ GO TO Q.6
Get a little worse ---------- 2	→ ASK b
Get a lot worse ---------- 1	
Don't know/Can't say ---------- 6	→ GO TO Q.6

(b) "Can you say why?" (RECORD FULLY)

_____

_____

_____

E. ***Questions on Purchase Change***

Introduction:
Please answer the next questions on the basis that New Zealand became one of two or three countries to use genetically modified plants, organisms, seeds and animals, in the ways we covered earlier.

Q.6a "Say you were at the shops, buying fruit. Some of the fruit was from New Zealand and some from countries that did not use genetic modification. Knowing that New Zealand used genetic modification technology, although not with the fruit that interested you, - would you feel…?" (READ OUT)

"More inclined to choose New Zealand fruit?" --- 1	→ ASK b
"Less inclined to choose New Zealand fruit?" ---- 2	→ ASK d
"Or no different than before?" ---------- 3	→ GO TO Q.7
Depends on looks/taste/variety etc. ---------- 4	→ GO TO Q.7

(b) "If the New Zealand fruit was priced at about 5 cents in the dollar dearer than similar fruit from countries who didn't use genetic modification, would you buy it at that price?" (READ OUT)

"Yes" ----------	1	→ GO TO c
"No" ----------	2	→ GO TO Q.7
Depends on looks/taste/variety etc. ---------- ---	3	→ GO TO Q.7

(c) "If the New Zealand fruit was priced at about 10 cents in the dollar dearer than similar fruit from countries who didn't use genetic modification, would you buy it at that price?" (READ OUT)

"Yes"---------- 1→ GO TO Q.7

"No"---------- 2 → GO TO Q.7

Depends on looks/taste/variety etc. ----------3 → GO TO Q.7

(d) "If the New Zealand fruit was priced at about 5 cents in the dollar less expensive than similar fruit from countries who didn't use genetic modification, would you then buy it?" (READ OUT)

"Yes"---------- 1→ GO TO Q.7

"No"---------- 2 → ASK e

Depends on looks/taste/variety etc. ----------3 → GO TO Q.7

(e) "And if the New Zealand fruit was priced at 10 cents in the dollar less expensive than similar fruit from countries who didn't use genetic modification, would you then buy it?" (READ OUT)

"Yes"---------- 1→ GO TO Q.7

"No"---------- 2 → ASK f

Depends on looks/taste/variety etc. ---------- 3 → GO TO Q.7

(f) "How many cents per dollar less expensive would the New Zealand fruit need to be for you to buy it?" (READ OUT)

"Cents per dollar cheaper _____ cents"------- 1

(PROBE ONLY IF NEEDED: "Would you say

12, 14, 16,18, 20, or over 20?")

"Would not buy it at all"---------- 2

Don't know/Can say ---------- 3

Q.7a "Now please think of taking a 10 day holiday in another country, and also that New Zealand was one of several countries you found equally appealing. On being told that New Zealand used genetic modification technology in the ways we covered, - would you feel…?" (READ OUT) (IF ASKED: *"You don't know whether the others do or don't use GM.")*

"More inclined to choose New Zealand for a holiday" -1→ ASK b

"Less inclined to choose New Zealand for a holiday"--2→ ASK d

"Or would make no difference to you"----------3→ GO TO Q.8

Depends on other things---------- 4→ GO TO Q.8

(b) "If it happened that the New Zealand holiday was priced 5% dearer than a similar holiday in countries that did not use genetic modification, would New Zealand…" (READ OUT)

"Still be equally appealing to the other countries
you were considering as a holiday choice" ----------1 → ASK c

"Now be less appealing than the other countries
you were considering as a holiday choice" ----------2 → GO TO Q.8

Depends on other things ----------3 → GO TO Q.8

(c) "If it happened that the new Zealand holiday was priced 10% dearer than a similar holiday in countries that did not use genetic modification, would New Zealand…" (READ OUT)

"Still be equally appealing to the other countries
you were considering as a holiday choice" ----------1 → GO TO Q.8

"Now be less appealing than the other countries
you were considering as a holiday choice" ----------2 → GO TO Q.8

Depends on other things ----------3 → GO TO Q.8

(d) "What if you could get the New Zealand holiday at a discount of 5% less than a similar holiday in countries that did not use genetic modification, would New Zealand…" (READ OUT)

"Still be less appealing than the countries
which don't use genetic modification" ----------1 → ASK e

"Now be equally or more appealing, again, to the
countries you were considering" ----------2 → GO TO Q.8

Depends on other things ----------3 → GO TO Q.8

(e) "What if you could get the New Zealand holiday for a discount of 10% over the price of a similar holiday in countries that did not use the sort of genetic modification technology we covered. Would New Zealand…" (READ OUT)

"Still be less appealing than other countries
which don't use genetic modification" ----------1 → ASK f

"Now be equally, or more appealing, again, to the
countries you were considering" ----------2 → GO TO Q.8

Depends on other things ----------3 → GO TO Q.8

(f) "What percent discount would you want, for New Zealand to be as appealing a holiday purchase, as countries which did not use genetic modification technology?"

"Discount_____ %" ---------- 1

(PROBE ONLY IF NEEDED: "Would you say

12, 14, 16,18, 20, or over 20?")

"Would not buy /Go at all" ---------- 2

Don't know/Can't say ---------- 3

Q.8a "Suppose you were at the shops buying a dairy product like cheese, a milk drink, or butter. The store had dairy products from New Zealand as well as from countries that did not use genetic modification in the ways we covered earlier.

Knowing that New Zealand used genetic modification, <u>though not in the dairy product you were buying</u>, would you feel…"(READ OUT)

"More inclined to buy the New Zealand dairy product" --1 → GO TO b

"Less inclined to buy the New Zealand dairy product"---2 → GO TO d

"Or would make no difference to you"----------3 → GO TO Q.9

Depends on looks/taste/variety etc.---------- 4 → GO TO Q.9

(b) "If the New Zealand dairy product was priced about 5 cents in the dollar <u>dearer</u> than similar products from countries which did not use genetic modification, would you buy it at that price…"(READ OUT)

"Yes"---------- 1 → GO TO Q.c

"No" ---------- 2 → GO TO Q.9

Depends on looks/taste/variety etc.----------3 → GO TO Q.9

(c) "If the New Zealand dairy product was priced about 10 cents in the dollar <u>dearer</u> than similar products from countries which did not use genetic modification, would you buy it at that price…"(READ OUT)

"Yes"---------- 1 → GO TO Q.9

"No" ---------- 2 → GO TO Q.9

Depends on looks/taste/variety etc. ---------- 4 → GO TO Q.9

(d) "If New Zealand dairy product were priced at about 5 cents in the dollar <u>less</u> expensive than similar dairy products from countries who didn't use genetic modification, would you then buy it?" (READ OUT)

"Yes"---------- 1 → GO TO Q.9

"No" ---------- 2 → ASK e

Depends on looks/taste variety etc ---------- 3 → GO TO Q.9

(e) "And if the New Zealand dairy products were priced at 10 cents in the dollar <u>less</u> expensive than similar dairy products from countries who didn't use genetic modification, would you then buy it?" (READ OUT)

"Yes"---------- 1 → GO TO Q.9

"No" ---------- 2 → ASK f

Depends on looks/taste variety etc ---------- 3 → GO TO Q.9

(f) "How many cents per dollar less expensive would New Zealand dairy products need to be for you to buy it?" (READ OUT)

Cents per dollar cheaper _____ cents --------- 1

(PROBE ONLY IF NEEDED: "Would you say

12, 14, 16,18, 20, or over 20?")

Would not buy it at all ---------- 2

Don't know/Can't say ---------- 3

Q.9a "Now suppose New Zealand were **not to use** genetically modified organisms in production, **nor** release GM organisms into the environment. Please answer the next questions on the basis that New Zealand became one of the two or three countries to **not use** genetic modification.

Say you were at the shops, buying fruit - some of the fruit was from New Zealand, and some from countries that did use genetic modification, the fruit itself was not genetically modified. Given that New Zealand did not use genetic modification technology, would you feel…"

"More inclined to choose New Zealand fruit?" --- 1 → ASK b

"Less inclined to choose New Zealand fruit?" ---- 2 → ASK e

"Or no different than before?" ---------- 3 → GO TO Q.10

Depends on looks/taste/variety etc. ---------- 4 → GO TO Q.10

(b) "If the New Zealand fruit was priced at about 5 cents in the dollar dearer than similar fruit from countries who **did** use genetic modification, would you buy it at that price?" (READ OUT)

"Yes" ---------- 1 → ASK c

"No" ---------- 2 → GO TO Q.10

Depends on looks/taste/variety etc. ---------- --- 3 → GO TO Q.10

(c) "If the New Zealand fruit was priced at about 10 cents in the dollar dearer than similar fruit from countries who **did** use genetic modification, would you buy it at that price?" (READ OUT)

"Yes"	1	ASK Q.d
"No"	2	GO TO Q.10
Depends on looks/taste/variety etc.	3	GO TO Q.10

(d) "How many cents per dollar more, would you be prepared to pay for the New Zealand fruit, than fruit from other countries that did use GM technology?" (READ OUT)

Cents per dollar more _____ cents	1	GO TO Q.10
(PROBE ONLY IF NEEDED: "Would you say 12, 14, 16,18, 20, or over 20?")		
Don't know/Can't say	2	GO TO Q.10

(e) "If New Zealand fruit was priced at about 5 cents in the dollar less expensive than similar fruit from countries who did use genetic modification, would you then buy it?" (READ OUT)

"Yes"	1	GO TO Q.10
"No"	2	ASK f
Depends on looks/taste variety etc	3	GO TO Q.10

(f) "And if the New Zealand fruit was priced at 10 cents in the dollar less expensive than similar fruit from countries who did use genetic modification, would you then buy it?" (READ OUT)

"Yes"	1	GO TO Q.10
"No"	2	GO TO Q.10
Depends on looks/taste variety etc	3	GO TO Q.10

F. ***Demographics***

Q.10a Gender (RECORD WITHOUT ASKING) Female - 1 Male - 2

(b) Country: Australia - 1 United States - 3
UK - 2
City (WRITE IN) _____

(c) Age Group: I'll read out a range of age groups. Please say "stop" when I get to the age group you fall into.

18 - 29 years - 1
30 - 39 years - 2
40 - 49 years - 3
50 - 59 years - 4
60 - 69 years - 5
70 or over - 6
DECLINED - 7

G. ***Thank And Terminate***

Thanks very much for your time and your view, we greatly appreciate your taking part.

CERTIFICATION: I hereby certify that this is a true and accurate record of an interview conducted by me at the time and with the person specified. TICK WHEN CHECKED: ☐

INTERVIEWER'S NAME: _____Date: _____
(Please print)

Supervisor Sign: _____Audit: _____

* * * * *

Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 3
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

Market Research Report: The effect of GMO release on market perceptions of the New Zealand Environment

Consumer Segment

FEBRUARY 2003

National Research Bureau

P O Box 10-118, Mt Eden, AUCKLAND. Phone (09) 6300 655, www.nrb.co.nz

CONTENTS

A. OBJECTIVES

This report forms part of a wider study undertaken by Business and Economic Research Limited (BERL) and the Agribusiness and Economics Research Unit (AERU), Lincoln University. The study, commissioned by the Ministry for the Environment, seeks to identify the key economic opportunities of, and risks from, the release of genetically modified organisms (GMOs) in New Zealand, and the effect of this on our clean green image.

The research undertaken by NRB comprises an international survey of both market buyers (gatekeepers) and consumers.

The objectives of this, the consumer survey, were as follows:

- To gauge overseas consumers' image of the New Zealand environment
- To gauge how this image would change in response to different scenarios in which GMOs are released into the New Zealand environment
- To measure overseas consumers' "willingness to pay", should New Zealand release GMOs into the environment
- To gauge the current likely market perception and reaction if New Zealand refrained from GMO release, while other countries did not.

* * * * *

B. SURVEY SPECIFICATIONS

Sample Size and Stratification

A net sample of 444 people were interviewed on the basis of one per household. Interviews were conducted in three countries as follows:

Australia	150
United Kingdom	150
United States	144

In order to focus the study on areas where New Zealand produce is thought to be more widely available, the following regions of each country were sampled:

Australia	- all
United Kingdom	- England
United States	- California, Oregon and Washington

Sample Source

Samples of randomly generated telephone numbers for each of the three countries were provided by specialised phone sample suppliers, operating within the market research industry.

Respondent Selection

Quota sampling was used to ensure an even balance of both male and female respondents, and of different age groups, with the samples stratified according to state, city or region to ensure proportional numbers in each. Respondents for interviews were aged 18 years or over.

Method

All interviewing was conducted by telephone, with calls being made on evenings and weekends as per the correct time zone(s) for each country. Calling times were as follows:

Australia	Weekday	6.00pm – 8.00pm, local time
	Weekend	10.00am – 8.00pm, local time
England	Weekend	10.00am – 7.00pm, local time
United States	Weekend	10.00am – 8.00pm, local time

Call backs

Three call backs. i.e. four calls in total, were made to a residence before the number was replaced in the sample. Callbacks were made on a different day and at a different time.

Survey Dates

All interviews were conducted in December 2002 and January 2003.

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C. EXECUTIVE SUMMARY

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".

Summary Table – 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.

Image Change

Approximately one-third of all respondents stated that their image of the New Zealand environment would get worse, should New Zealand use GMOs in pest control or livestock feed.

1. Respondents were more tolerant of the use of GMOs in disease prevention, with only 19% overall stating that their view of the New Zealand environment would worsen under this scenario. Conversely, 39% of all respondents said that New Zealand's environmental image would improve.
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.

Summary Table - How Respondents' Image of the New Zealand Environment Would Change Under Different 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.

Purchase Change

1. When confronted with a scenario in which the respondent was choosing a non-GM product, that came from a country which used genetic modification (GM) in other ways, the majority of respondents said that 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.
2. Between one-quarter and one-third of respondents said that they would be less inclined to purchase the product under the fruit and dairy scenarios. Of these respondents, the majority stated that they 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.
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, with approximately 90% feeling no different to before, or feeling more inclined to purchase New Zealand fruit. The majority of respondents were prepared to buy this product with a premium applied.

Summary Table - How Respondents' Purchasing Behaviour Would Change Under Different Scenarios

		Purchasing Fruit %	Choosing Holiday %	Purchasing Dairy Prod. %	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.

Cautionary Notes

1. In generalising from scenarios as presented in a research setting to the real market equivalent, we should be aware that two influences pull strongly toward a fading of the research-measured reaction. 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 genetic modification (GM) attributes of New Zealand in other contexts. Secondly, the price-quality characteristics of the product, relative to those from other countries will assume a powerful if not predominant influence in the product choice, including in particular trade-offs of immediate tangibles (cost, appeal) against intangible and more remote perceptions of GMOs.
2. The durability of the above figures will depend on the dissemination of favourable, unfavourable and neutral information about GMOs, and the way this is received by the public. 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.

* * * * *

D. FINDINGS IN DETAIL

1. Relative Image of the New Zealand Environment

"I'll read out the names of some countries. Would you please answer by saying whether your image of their environment was…

very good, among the best,

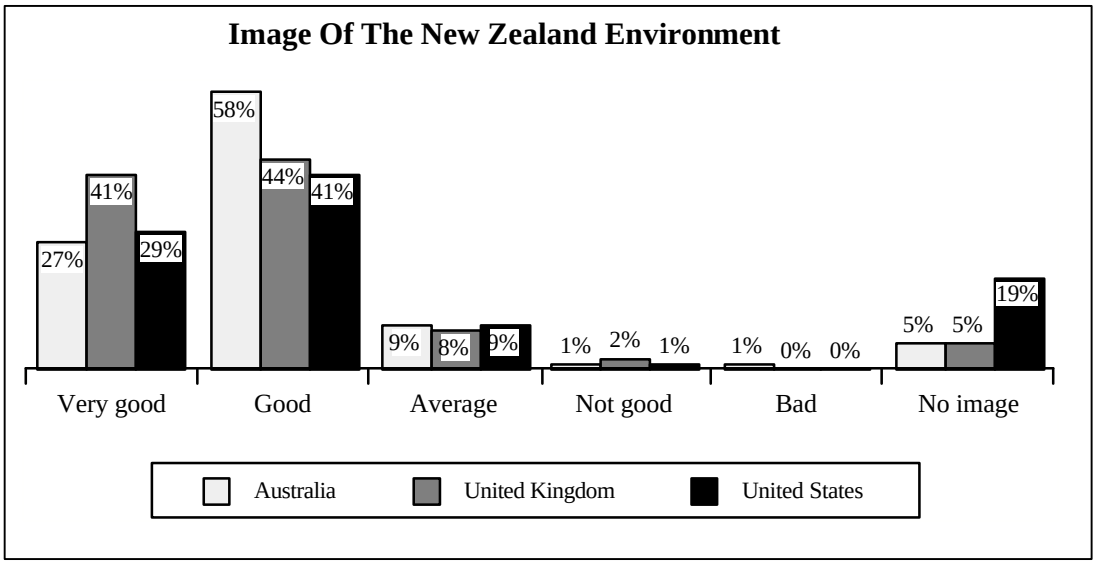
OR just good, above the average,

OR average, say in the middle,

OR not very good, below the average,

OR relatively bad, among the worst.

Of course if <u>no</u> image comes to your mind at all, just say "no image "."



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

- The image of the New Zealand environment was "Good, above the average" amongst the majority of respondents, and across all three countries.

- New Zealand's image is best in the United Kingdom, where 41% of respondents rated the New Zealand environment "Very Good – Among the Best", as compared to 29% in the United States and 27% in Australia.

- A large number (19%) of United States respondents had no image of the New Zealand environment.

Relative Image of the Environment of Selected Countries - Respondents Rating Country "Very Good - Among the Best" or "Good - Above the Average"

	Australia % (Rank)	United Kingdom % (Rank)	United States % (Rank)
New Zealand	85 (1)	85 (1)	70 (2)
Switzerland	77 (2)	83 (2)	77 (1)
Canada	77 (2)	78 (3)	69 (3)
Australia	63 (4)	67 (4)	55 (4)
Netherlands	49 (5)	55 (5)	47 (5)
Japan	29 (6)	27 (6)	27 (8)
United Kingdom	27 (7)	24 (7)	31 (7)
United States	21 (8)	20 (9)	33 (6)
South Africa	11 (9)	21 (8)	15 (9)
Thailand	11 (9)	10 (11)	11 (11)
China	11 (9)	9 (12)	9 (12)
Argentina	5 (12)	11 (10)	12 (10)
Mexico	5 (12)	7 (13)	4 (13)

- When compared with a number of other countries, the image of New Zealand's environment consistently ranked highly, along with Switzerland and Canada, and ahead of Australia.

- Nearly all respondents (85%) in Australia and the United Kingdom felt that the New Zealand environment is "Very Good – Among the Best" or "Good – Above Average". This number was significantly lower in the United States (70%).

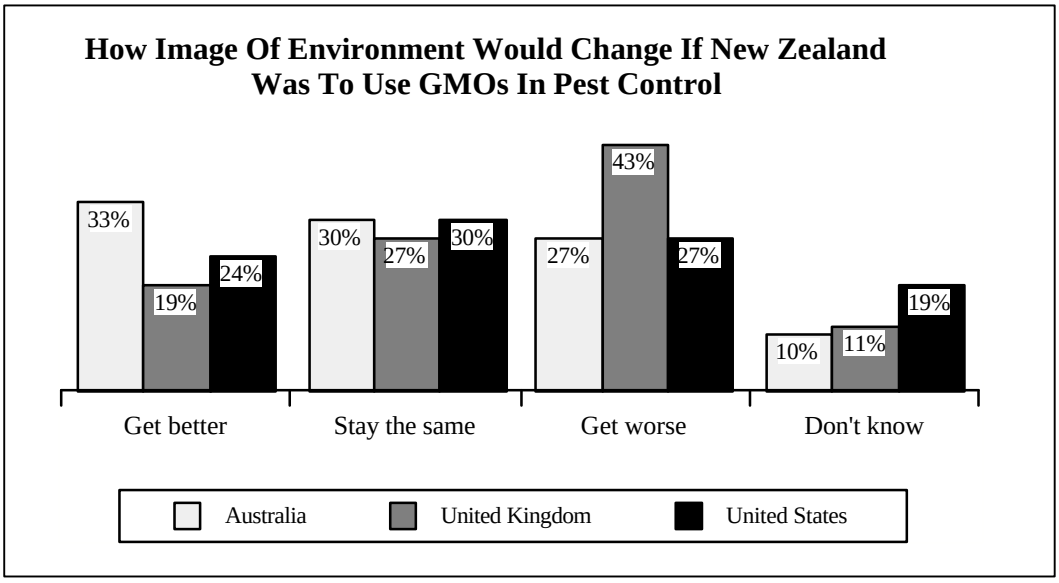
- As a result New Zealand ranked highest of the selected countries, when put to Australian and English respondents. In contrast, more American respondents rated Switzerland's environment "Good" or "Very Good", than they did New Zealand's.

2. Image Change – GMOs In Pest Control

"Suppose New Zealand was one of two or three countries that used genetic technology to control local pests such as rats or wasps. For example, a gene which caused them to breed less often was put into a number of rats or wasps. These are then released to mix with those in the wild so that the gene is passed around."

"Would your image of that country's environment get better, stay the same, or get worse?"

If better or worse*: "Can you say why?"*



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

- Given the pest control scenario, the majority of respondents felt their image of New Zealand would worsen. Those in the United Kingdom were most averse to using GMOs to control pests with 43% stating that their image of New Zealand would get worse. This compares with just over a quarter (27%) of Australian and American respondents.
- Approximately one-quarter of respondents felt that their image of the New Zealand environment would stay the same. This peaked at 30% in Australia and the United States.
- A smaller number said that their image of the environment would get better. Australian respondents were most open to the idea of GMOs for pest control, with 33% saying that New Zealand's image would improve.
- A relatively large proportion of respondents did not know how their image of New Zealand would change, particularly those respondents from the United States (19%).

Comments Regarding the Use of GMOs In Pest Control

	Australia %	United Kingdom %	United States %
Positive Comments (Top Five Mentions)			
It would be an improvement	5	7	5
Should be controlled	6	4	6
Eradicate pests	9	4	2
There would be less pests	8	2	5
Helping the environment	7	3	4
Negative Comments (Top Four Mentions)			
Interfering with nature	7	17	10
Could be dangerous/have side effects	8	10	13
Don't know the consequences	7	8	6
Don't approve of GM technology	5	11	4

NB. Multiple Responses. Each respondent was permitted to give more than one answer.

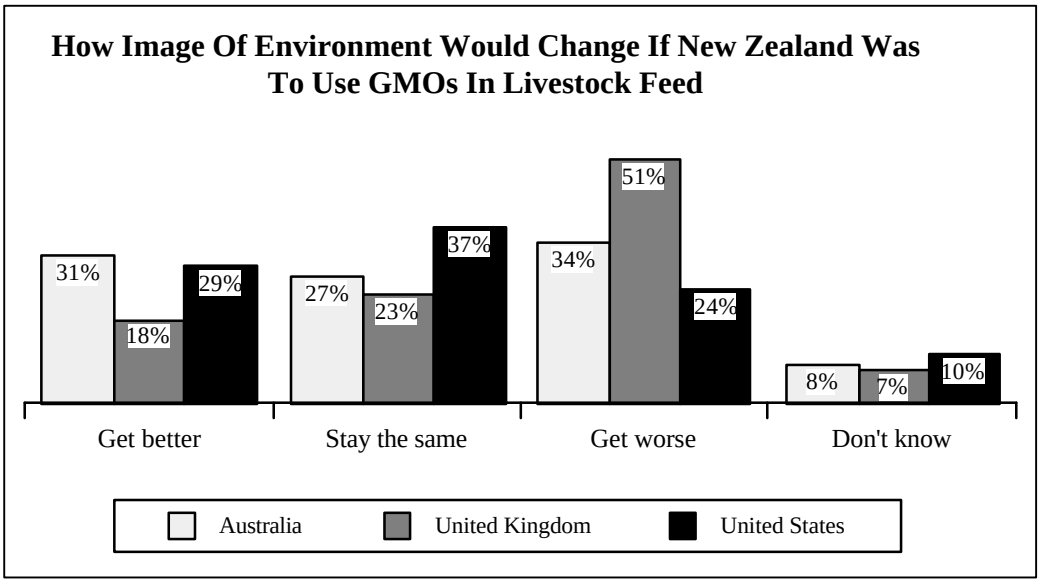
- Positive comments made regarding the use of GMOs in pest control, included that there would be less pests, pests should be controlled, and that it would help the environment.
- A large number of Australian respondents were in favour of the use of GMOs as per this scenario, as such measures would eradicate pests (9%), or there would be less pests (8%).
- The most common negative comments were that the use of GMOs to control pests would interfere with nature and that it could have side effects. Respondents also stated that the consequences of using GMOs were unknown, or that they simply did not approve of GM technology.
- A large number of respondents in the United Kingdom (17%) were concerned that the use of GMOs would interfere with nature.
- Conversely, American respondents (13%) were worried that there may be side effects when using GMOs.

3. Image Change - GMOs in Livestock Feed

"Suppose New Zealand was one of two or three countries to use a strain of rye grass modified by genetic technology. The gene of the grass would be changed to increase its food value. Farmers would plant fields of the modified rye grass to feed their livestock."

"Would your image of that country's environment get better, stay the same, or get worse?"

If better or worse: *"Can you say why?"*



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

- When confronted with a scenario in which rye grass was genetically modified in order to feed livestock, the majority of respondents said that their image of the New Zealand environment would worsen.
- This was particularly the case in the United Kingdom, where over half (51%) of respondents said New Zealand's environmental image would get worse. In comparison, 34% of Australian, and 24% of American respondents felt this way.
- The majority (37%) of respondents in the United States felt that their image of New Zealand would remain unchanged.
- Around one quarter of all respondents, felt that their image of the environment would improve, ranging from 18% of United Kingdom respondents to 31% of Australians.

Comments Regarding the Use of GMOs in Livestock Feed

	Australia %	United Kingdom %	United States %
Positive Comments (Top Five Mentions)			
It would be an improvement	7	8	11
Produce more feed for animals	7	5	9
Better quality food for livestock	9	3	6
More animals per paddock	4	2	7
Better grass so better animals	6	1	6
Negative Comments (Top Five Mentions)			
Could be dangerous	7	15	8
Interfering with nature	3	17	8
Don't approve of GM technology	7	14	6
Don't know the consequences	6	13	6
Could get into the food chain	7	8	6

NB. Multiple Responses. Each respondent was permitted to give more than one answer.

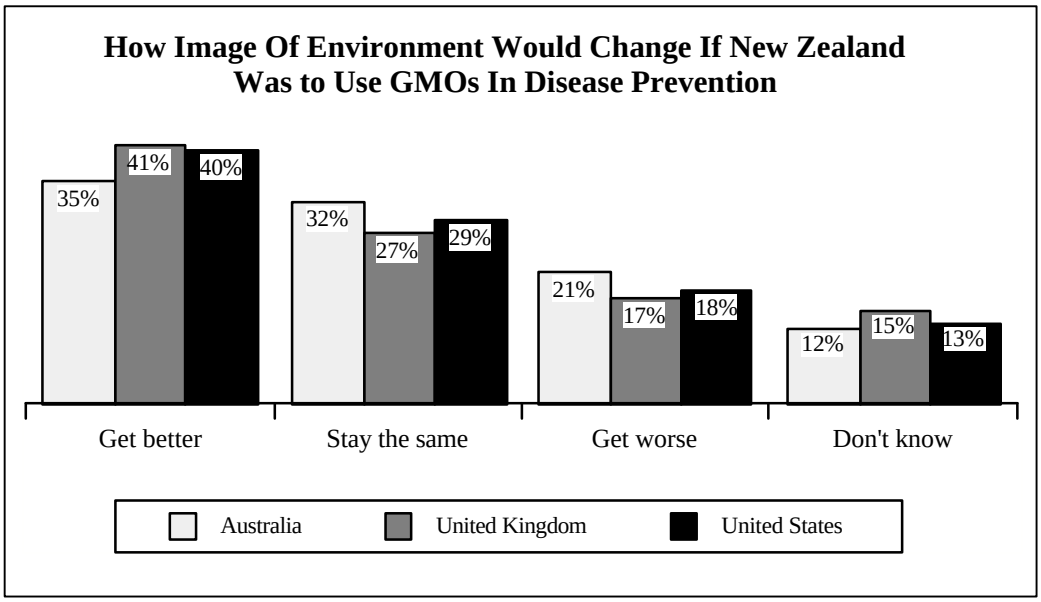
- Negative comments regarding this scenario included that it could be dangerous, it interfered with nature and that the consequences were unknown. Some respondents were also concerned that GMOs could get into the food chain. As in the previous scenario, there were a number of people who did not approve of GM technology.
- As shown in the preceding graph, respondents from the United Kingdom were most concerned about the use of genetically modified rye grass. 17% of respondents stated that this interfered with nature, while 15% said that it could be dangerous.
- Positive comments tended to centre on genetically modified rye grass producing more, or better quality feed, and the knock-on benefits to the quantity and quality of livestock.
- American respondents placed greater importance on the quantity of feed (9%), while 9% of Australians said that better quality feed would result from the use of GMOs.

4. Image Change - GMOs in Disease Prevention

"Suppose New Zealand was one of two or three countries to use a virus whose genes have been changed in such a way that protects a person against a contagious disease such as Hepatitis or Meningitis. The modified virus, once in the person's bloodstream, would remain there, attacking the disease virus if or when the person got infected."

"Would your image of that country's environment get better, stay the same, or get worse?"

If better or worse: *"Can you say why?"*



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

- Respondents were, on the whole, more tolerant in a scenario where genetically modified viruses were used to protect against disease. Over one third of all respondents stated that their image of the New Zealand environment would improve under this scenario. Acceptance was highest in the United Kingdom (41%).
- Around 20% of respondents felt their view of the environment would worsen, peaking at 21% in Australia.
- Approximately 30% of respondents said there would be no change in image, ranging from 27% in the United Kingdom to 32% in Australia.

Comments Regarding the Use of GMOs in Disease Prevention

	Australia %	United Kingdom %	United States %
Positive Comments (Top Five Mentions)			
Would be good	7	18	13
Good for health reasons	9	11	17
Control diseases	12	9	12
Prevent diseases	3	11	8
Reduce diseases	5	5	4
Negative Comments (Top Four Mentions)			
Is dangerous/too much risk involved	8	9	9
Don't approve of GM technology	5	3	6
No idea of outcome	3	5	4
Nervous about using in humans	3	3	4

NB. Multiple Responses. Each respondent was permitted to give more than one answer.

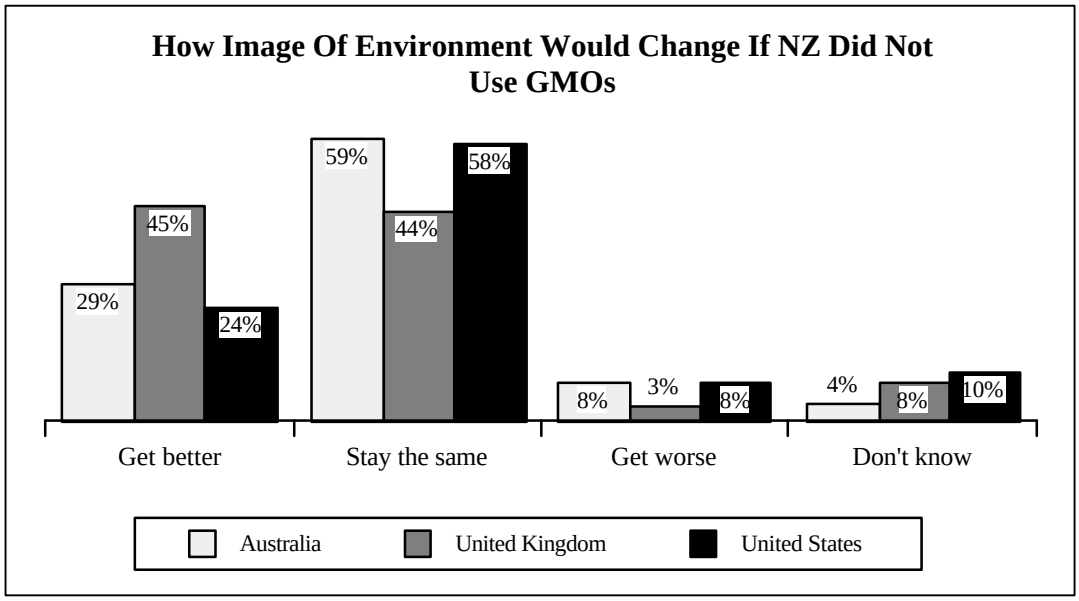
- Positive comments regarding the use of GMOs for disease prevention centred on the reduction, prevention and control of disease. This was especially so in the United States, where 17% of all respondents said their image would improve, as such a use would be good for health reasons.
- The main comment made in opposition to this use of GMOs, was that it was too dangerous. This view was expressed by 8% of Australian, and 9% of English and American respondents.
- Other negative comments included that the outcome was unknown, and that the respondent was nervous about the use of GMOs in humans. Some respondents expressed once again that they did not approve of GM technology.

5. Image Change - No Use of GMOs

*"Suppose New Zealand was one of two or three countries **not to use** genetically modified organisms in production, **nor** release GM organisms into the environment."*

"Would your image of that country's environment get better, stay the same or get worse?"

If better or worse: *"Can you say why?"*



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

- Respondents were far more positive, when considering that New Zealand not use GMOs.
- Almost half (45%) of United Kingdom respondents said their image of New Zealand's environment would improve should it not use GMOs.
- The majority of Australian (59%) and American (58%) respondents said that their image of the New Zealand environment would stay the same if GMOs were not used.
- Only a small number said that their view would get worse, peaking at 8% in Australia and the United States.

Comments Regarding New Zealand not Using GMOs

	Australia %	United Kingdom %	United States %
Positive Comments (Top Four Mentions)			
Don't approve of GM technology	8	17	8
It is natural	9	12	11
It is healthier/safer without GM	6	10	4
Reinforces positive image of New Zealand	4	6	4
Negative Comments (Top Three Mentions)			
Health reasons	5	1	1
Approve of GM technology	1	2	4
Progressive	2	-	4

NB. Multiple Responses. Each respondent was permitted to give more than one answer.

- One of the primary reasons as to why respondents looked favourably on New Zealand not using GMOs, was that respondents did not approve of GM technology. This was most evident in the United Kingdom, where this was stated by 17% of respondents.
- Respondents also felt that New Zealand being GMO-free was more natural, and healthier.
- A smaller number of respondents felt that New Zealand being free of GMOs would reinforce New Zealand's positive image.
- Negative comments included that GM technology was good for health reasons in terms of disease prevention, the respondent approved of GM technology, and GM was a progressive technology.

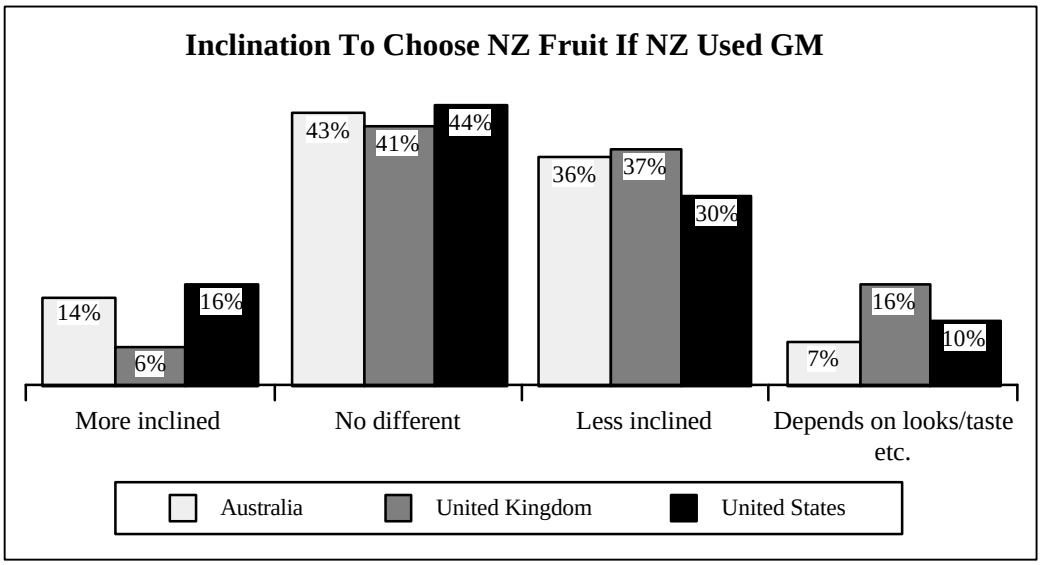
6. Purchase Change - Purchasing Fruit

"Say you were at the shops, buying fruit. Some of the fruit was from New Zealand and some from countries that did not use genetic modification. Knowing that New Zealand used genetic modification technology, although not with the fruit that interested you, would you feel…?"

"More inclined to choose New Zealand fruit?"

"Less inclined to choose New Zealand fruit?"

"Or no different than before?"



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

- The majority of respondents (between 41% and 44%) said they would feel no different to before, if New Zealand used GM technology, although not with the fruit that interested them.

- Around one third would be less inclined to purchase New Zealand fruit, should it use GM technology. English (37%) and Australian (36%) respondents were less tolerant to the use of GM in this scenario, as compared with respondents in the United States (30%).

Inclination to Purchase New Zealand Fruit under GM Scenario

	Australia %	United Kingdom %	United States %
More Inclined…	**14**	**6**	**16**
Would buy with no premium	3	1	2
Would buy with 5 cent premium	1	1	1
Would buy with 10 cent premium	6	4	8
Depends on looks/taste etc	4	-	5
Less Inclined, but…	**36**	**37**	**30**
Would buy with 5 cent discount	2	3	3
Would buy with 10 cent discount	1	-	2
Would buy with 10+ cent discount	2	2	1
Wouldn't buy with any discount	27	30	20
Don't know	2	-	1
Depends on looks/taste etc	3	3	3

NB. Percentages may not add to 100 due to rounding

- The overwhelming response from those that would be less inclined to buy New Zealand fruit in the given scenario, was that they wouldn't buy the fruit, even if a discount was given. This was highest in the United Kingdom, where 30% of all respondents said that they would not purchase this fruit at any cost.

- The number of respondents more inclined to buy New Zealand fruit was relatively low, ranging from 6% in the United Kingdom to 16% in the United States.

- Of those stating that they would be more inclined to buy such fruit, many said that they would buy this with a 10 cent premium.

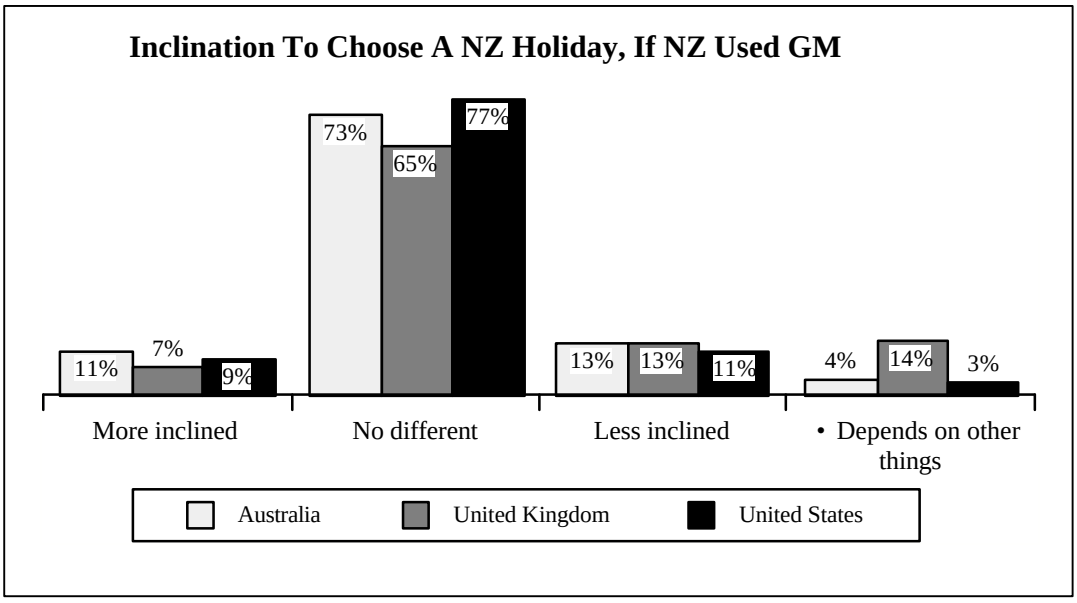
7. Purchase Change - Choosing a Holiday

"Now please think of taking a 10 day holiday in another country, and also that New Zealand was one of several countries that you found equally appealing. On being told that New Zealand used genetic modification technology in the ways we covered, would you feel…?"

"More inclined to choose New Zealand for a holiday?"

"Less inclined to choose New Zealand for a holiday?"

"Or would make no difference to you?



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

- The majority of respondents said they would feel no different about choosing a New Zealand holiday, should New Zealand use GM technology. This ranged from 65% in the United Kingdom to 77% in the United States.

- The number of respondents stating that they would be less inclined to choose a New Zealand holiday, was relatively low, peaking at 13% (Australia and the United Kingdom).

- Similarly, there were only a small number of respondents who felt more inclined to choose New Zealand holiday under the given scenario, peaking at 11% (Australia).

Inclination to Choose a New Zealand Holiday under GM Scenario

	Australia %	United Kingdom %	United States %
More Inclined, but would be equally, or more appealing than other countries if…	**11**	**7**	**9**
No premium	1	1	1
5% dearer	1	-	1
10% dearer	5	3	5
Depends on other things	5	3	1
Less Inclined, but would be equally, or more appealing than other countries if…	**13**	**13**	**11**
5% discount	1	2	1
10% discount	1	-	1
10+% cent discount	1	2	2
Wouldn't choose with any discount	9	6	5
Don't know	-	1	-
Depends on other things	2	3	1

NB. Percentages may not add to 100 due to rounding

- Of those less inclined to purchase a New Zealand holiday under the given scenario, the majority stated that they would not choose New Zealand even if a discount were given. This accounted for 9% of all respondents in Australia, 6% of those from the United Kingdom, and 5% of those in the United States.

- Around one in twenty (5%) respondents in Australia and the United States said that New Zealand would be an equally appealing holiday destination, even if it was over 10% dearer than a similar holiday in a country that did not use GM technology.

8. Purchase Change - Purchasing Dairy Products

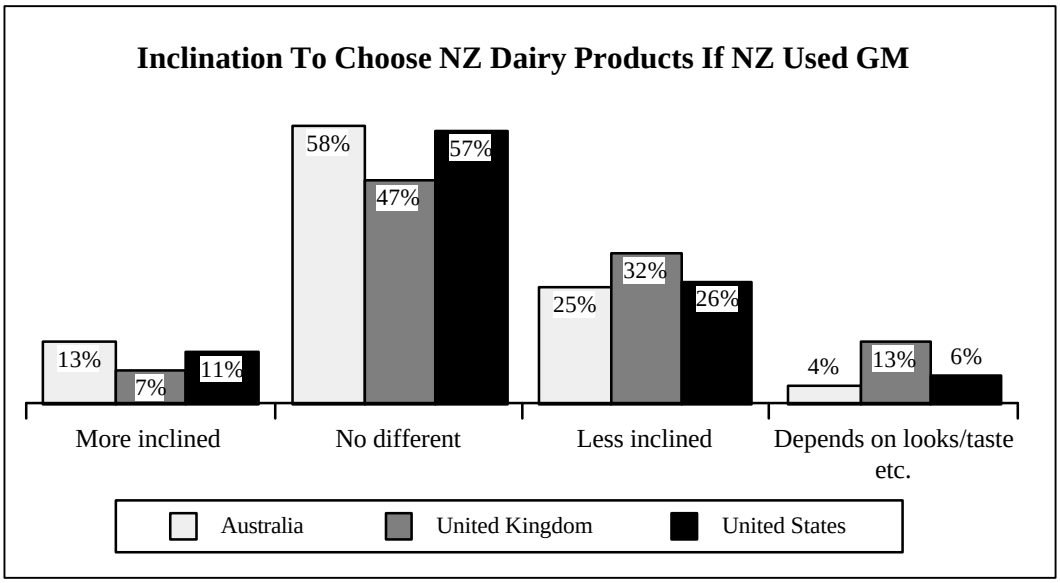
"Suppose that you were at the shops buying a dairy product like cheese, a milk drink, or butter. The store had dairy products from New Zealand as well as from other countries that did not use genetic modification in the ways we covered earlier."

"Knowing that New Zealand used genetic modification, though not in the dairy product you were buying, would you feel…"

"More inclined to buy the New Zealand dairy product?"

"Less inclined to buy the New Zealand dairy product?"

"Or would make no difference to you?"



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

- The majority of respondents were indifferent with regards to purchasing a New Zealand dairy product, which had not been genetically modified itself, but which came from a country that used GM in other ways. This was highest in Australia (58%) and the United States (57%).

- United Kingdom respondents were the least inclined (32%) to buy such a dairy product. This compares to 25% of Australian and 26% of United States respondents, who said they would be less inclined to purchase the product.

- Few respondents were more inclined to purchase the New Zealand dairy product. This ranged from 7% in the United Kingdom to 13% in Australia.

Inclination to Purchase New Zealand Dairy Products under GM Scenario

	Australia %	United Kingdom %	United States %
More Inclined…	**13**	**7**	**11**
Would buy with no premium	1	1	3
Would buy with 5 cent premium	1	1	1
Would buy with 10 cent premium	11	3	7
Depends on looks/taste etc	1	3	1
Less Inclined, but…	**25**	**32**	**26**
Would buy with 5 cent discount	1	1	1
Would buy with 10 cent discount	1	-	2
Would buy with 10+ cent discount	1	1	-
Wouldn't buy with any discount	21	29	21
Don't know	1	-	1
Depends on looks/taste etc	1	1	1

NB. Percentages may not add to 100 due to rounding

- Once again, a very large number of respondents, said that they would not purchase the product even if it came at a discount. This was particularly the case in the United Kingdom, where 29% of all respondents stated that they would not purchase the dairy product at any price. Similarly, 21% of respondents in Australia and the United States said that they would not purchase the product.

- A much smaller number of respondents were more inclined to buy the product, with a number of these prepared to purchase with a 10 cent premium.

9. Purchase Change - No Use of GMOs

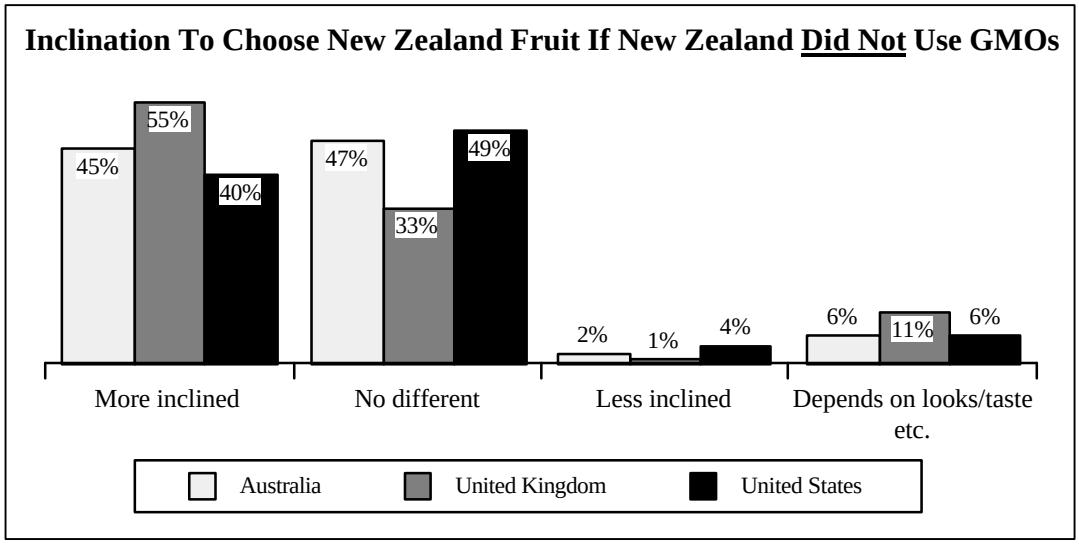
*"Now suppose New Zealand were **not to use** genetically modified organisms in production, **nor** release GM organisms into the environment. Please answer the next questions on the basis that New Zealand became one of the two or three countries to **not** use genetic modification."*

"Say you were at the shops, buying fruit – some of the fruit was from New Zealand, and some from countries that did use genetic modification, the fruit itself was not genetically modified. Given that New Zealand did not use genetic modification technology, would you feel…"

"More inclined to choose New Zealand fruit?"

"Less inclined to choose New Zealand fruit?"

"Or no different than before?"



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

- Under a scenario in which New Zealand did not use GMOs, the majority of respondents were either more inclined to purchase New Zealand fruit, or felt no different than before.
- Not using GMOs had the greatest effect on United Kingdom respondents, with over half (55%) stating that they would be more inclined to buy New Zealand fruit.
- The majority of Australian (47%) and United States (49%) respondents were indifferent, should New Zealand not use GMOs.
- Only a very small number (between 1% and 4%) of respondents said that they would be less inclined to buy the fruit, under the non-GMO scenario.

Inclination to Purchase New Zealand Fruit With Associated Premiums and Discounts Under Non-GMO Scenario

	Australia %	United Kingdom %	United States %
More Inclined…	**45**	**55**	**40**
Would buy with no premium	2	3	4
Would buy with 5 cent premium	3	2	3
Would buy with 10 cent premium	-	-	-
Would buy with 10+ cent premium	29	27	22
Depends on looks/taste etc	3	12	5
Don't know	9	12	8
Less Inclined, but…	**2**	**1**	**4**
Would buy with 5 cent discount	-	1	1
Would buy with 10 cent discount	1	-	-
Wouldn't buy with any discount	1	-	1
Depends on looks/taste etc	-	-	1

NB. Percentages may not add to 100 due to rounding

- The majority of those more inclined, said that should New Zealand not use GMOs, they would be prepared to pay a premium of ten cents or more. This was the case for 29% of respondents in Australia, 27% in the United Kingdom, and 22% in the United States.

* * * * *

APPENDIX

Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 4
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

Market Research Report: The effect of GMO release on market perceptions of the New Zealand environment

Gatekeeper segment

JANUARY 2003

CONTENTS

A. OBJECTIVES

This report forms part of a wider study undertaken by Business and Economic Research Limited (BERL) and the Agribusiness and Economics Research Unit (AERU), Lincoln University. The study, commissioned by the Ministry for the Environment, seeks to identify the key economic opportunities and risks from the release of genetically modified organisms (GMOs) in New Zealand.

The research undertaken by NRB comprises an international survey of both market buyers (gatekeepers) and consumers.

The objectives of the Gatekeeper survey are to:

1. Gauge Gatekeepers' image of the New Zealand environment

2. Explore Gatekeepers' corporate policies on genetically modified products

3. Determine if there would be any change in Gatekeepers purchase behaviour, should New Zealand release GMOs into the environment

* * * * *

B. SURVEY SPECIFICATIONS

Sample

The sample consisted of three major food retail chains in each of Australia, the United Kingdom, and the United States.

The most suitable person to talk to was established at the beginning of each call. This varied between companies from the buyer to the corporate affairs officer and the general manager.

Method

All interviewing was conducted by telephone, during working hours.

Survey Dates

All interviews were conducted in January 2003.

Note

- Interviewees represented their company's view to the best of their ability, and in good faith. Inferences, beyond those that can be sustained by a single executive interview, should naturally not be made.

- Interview responses have been supplemented with publicly available information (from annual reports, websites etc), where possible and appropriate.

* * * * *

C. FINDINGS IN DETAIL

1. AUSTRALIA - SUMMARY

GM Products

Food Standards Australia New Zealand regulates the sale of GM foods in Australia. The standard requires a mandatory pre-market safety assessment, and mandatory labelling. The policy of the three companies is to meet these requirements.

There was a general feeling that the food retailer would provide as much information to the consumer as required, leaving the decision on whether or not to buy GM products to the consumer. However, it was indicated that a shift in public opinion away from GM foods could cause a rethink of their position.

With regard to the use of GM in animal feed, companies stated that while they would like to be able to identify where products had been GM-fed (due to consumer demand), this was not possible. Two of the interviewees also referred to the Greenpeace campaign to remove GM from animal feed.

Non-GM Products

All companies were prepared to stock products that were not genetically modified, but came from a country that used GM in other ways, provided that the product conformed to Government health and safety regulations. Similarly, they would be prepared to sell such products under their own label.

Own-Label Products

All companies would stock a GM or non-GM product from a country using GM, under their own label.

Purchase Change

Interviewees reported that they did not differentiate on price, between GM and non-GM products. Pricing was determined by the cost of the product and the desired return on that product.

The New Zealand Environment

While the companies did not have a corporate view of the New Zealand environment, all said that it was a source of good quality produce. In addition, each interviewee said that New Zealand using GM in various ways would not affect their view of New Zealand, under current company policy.

COLES

GM Products

Coles sees no issue in stocking GM foods. Their policy is to label GM foods, in accordance with Food Standards Australia New Zealand regulations. Stocking decisions are based on *"what people want to buy"*.

Consumers are also demanding transparency in the labelling of products, and are becoming increasingly concerned about GM-fed products. However, Coles does not feel that the necessary framework is in place to identify food products from GM-fed animals.

> *"…we would like clear labelling and we would like the mechanisms within the food chain to enable that to occur, then let the customer decide."*

Non-GM Products

Coles had not received any correspondence from consumers regarding products that were not genetically modified, but came from countries that used GM in other ways.

Own-Label Products

Coles does sell own-label products that have been genetically modified. They have in the past tried to source GM-free products and declare them as such, however this has proven difficult in reality.

Purchase Change

Coles would not expect a discount for a GM-product, with products being priced according to the cost of the product to Coles. Similarly, they would not price a non-GM product from a GM country any differently to any other product.

> *"We don't differentiate our pricing on the basis of the country of origin, or whether its GM or what. We base it on the cost of the product and what our final return is going to be."*

The New Zealand Environment

The interviewee was unable to give the company's opinion on the New Zealand environment. However, when asked how the company would view New Zealand should it use GM, he stated that they had not changed their view of American and Canadian products. Provided a country supplied products that consumers wanted to buy, there would be no issue.

FOODLAND

GM Products

Foodland sees no issue with the sale of GM food. However, GM foods are labelled accordingly, as the consumer expects this.

> *"…if it's perfectly clearly labelled so the consumer knows exactly what they're buying and they choose to buy it, well that's fine."*

The interviewee went on to state that the company probably would not deal with a supplier that had a GM product that was not labelled.

However, the interviewee did express that, should consumers move away from GM products, they would stop stocking them.

> *"So therefore its not sensible for us as retailers to try and sell products that the consumer doesn't want to buy."*

Non-GM Products

Foodland would source non-GM products from countries that used GM, if this was acceptable practice.

Own-Label Products

The company would probably sell a genetically modified product under its own label.

Purchase Change

A discount on a GM product was not seen to be of any benefit, as cost would be dependent on the quality of the product, and the price of the product at the checkout was dependent on what the consumer was prepared to pay for it.

The New Zealand Environment

While the company does not have a view of the New Zealand environment, the interviewee did express that produce coming from New Zealand is generally of good quality. Should New Zealand use GM, the interviewee felt that the company's view of New Zealand would remain unchanged, as *"it comes back to what the market will accept."*

WOOLWORTHS

GM Products

Woolworths' policy requires that they know whether or not products conform to Food Standards Australia New Zealand regulations. Accordingly they would stock GM products provided they conform to these standards.

The interviewee suggested that GM had a lower profile in Australia.

> *"It's a hotter issue in New Zealand than it is here quite frankly. Obviously it's an issue, but it's not quite got the wide publicity that it's had in New Zealand for several years.*

However, he did suggest that the company would need to move towards a more proactive regime if opinion in Australia were to change.

Non-GM Products

Once again, so long as the product conformed to the relevant standards, the company would stock a non-GM product from a country that used GM in other ways.

Own-Label Products

Likewise, they would stock GM products under their own label, provided that the product met all standards, and all labelling was absolutely clear.

Purchase Change

Woolworths currently don't differentiate between GM and non-GM products in terms of price. Pricing would be determined by the cost of the product to the company.

The New Zealand Environment

Once again, the interviewee was unable to give a corporate view of the New Zealand environment. He did say that New Zealand was a source of high quality produce. If the company were to source products from New Zealand, New Zealand's GM status would have no impact.

2. UNITED KINGDOM - SUMMARY

GM Products

The three British supermarket chains stock GM foods, all of which are labelled according to European Council regulations. However, due to customer concerns about GM foods, the supermarkets tend to be careful as to which GM products they stock, and are increasing their range of non-GM foods.

Non-GM Products

Two of the interviewees were able to state their company's position on non-GM foods sourced from countries that used GM in other ways. One of the companies was unconcerned by this, while the other would consider products on a case-by-case basis.

Own-Label Products

All three companies had removed GM products and ingredients from their own-label foods. In addition they are moving away from products from animals fed a GM diet. Two of the companies would stock a non-GM product from a country using GM. One of the interviewees stated that they would stock the product provided there were no consumer safety issues, or negative impacts on consumer perceptions of their own-brand. The other company would want to ensure that the product had not come into contact with GM sources in any way.

Purchase Change

GM products, or non-GM products from a GM country, would not be differentiated on price.

The New Zealand Environment

Interviewees had no concerns about the New Zealand environment. However, they were more guarded when asked if this image would change, should New Zealand move towards the use of GM. One stated that such a move would be out of keeping with public perceptions in Europe, while the other said that products would need to be considered on a case-by-case basis.

SAINSBURY'S

GM Products

Sainsbury's will sell GM products that are labelled correctly. However, the interviewee stated that their customers had rejected GM products so completely that GM products tended not to sell. As a result, Sainsbury's are careful regarding which products they stock.

Non-GM Products

Sainsbury's would be prepared to stock a non-GM product from a country that was using GM for other purposes. They are solely concerned with GM products.

Own-Label Products

In response to customer demand, GM ingredients have been eliminated from all own-brand food. This was achieved by replacing soya and maize with alternative ingredients, or by using validated non-GM sources. Sainsbury's now also provides a range of products from animals fed a non-GM diet.

The interviewee did state that there would be an issue if the product, while not GM itself, could have come into contact with GM.

> *"… say for instance you had wheat, wheat that wasn't GM, coming from a country that was actually growing GM soy, we'd want to make sure that wheat wasn't contaminated, so we wouldn't reject the wheat per se. We'd say to people, hang on, just make sure you've not got any GM soy coming in through this wheat."*

The New Zealand Environment

Sainsbury's has no concerns about the New Zealand environment. When asked if this would change should New Zealand use GM, the interviewee said that the company would need to ensure that there was no impact on the products that they were buying.

> *"When we found out what GM things you'd (the New Zealand Government) approved, we could then look at what we were buying from you and see if there was any potential conflict."*

TESCO

GM Products

Tesco currently sells GM products, although due to customer concern over GM, Tesco has been increasing the number of non-GM food options available to consumers.

Non-GM Products

Non-GM products sourced from a country that used GM in other ways, would be considered on a case-by-case basis.

Own-Label Products

Tesco has removed GM ingredients from its own-brand products, and is now asking farmers to replace GM maize and soya with non-GM alternatives. Any decision on whether to sell under their own brand, a non-GM product from a country using GM, would be dependent on consumer demand for the product. Its impact on consumer perception of the Tesco brand, and any consumer safety issues would also be considered. If Tesco was not confident that a supplier was able to segregate and isolate non-GM material, they would not accept the product.

Purchase Change

Once again, GM products would be considered on a case-by-case basis, but would not be differentiated from other products on price.

> *"… it would have to be sold within our standard brand at a standard price that's competitive against our other origins, or we wouldn't sell it…"*

The New Zealand Environment

Tesco does not have a company view of the New Zealand environment. The interviewee stated her personal view, that the general perception in the UK is:

"… New Zealand always stands for a very clean, healthy living environment … our hopes would be that it retains that image."

Likewise, her personal view should New Zealand start to use GM:

> *"I think everybody in Europe would be concerned that you've taken that line at a rather early stage, so you're jumping ahead of the perceptions of customers within Europe."*

WAITROSE

GM Products

Waitrose will stock and sell GM products, although not under their own label. All GM products are labelled as per European Council regulations, which require the labelling of food and food ingredients made from GM maize and soya.

Own-Label Products

GM ingredients have been removed from all Waitrose own-label foods.

"We do not buy GM foods at the moment … because I don't think there's enough confidence in the market place in their advantages or disadvantages…"

The company has also started to move away from GM feed, with a number of suppliers now using more traditional crops to feed livestock. As a result, Waitrose now offers a range of non-GM-fed meat.

3. UNITED STATES - SUMMARY

GM Products

The three companies studied stock GM foods. Each has a policy to follow Food and Drug Administration regulations regarding the labelling of GM foods. These regulations stipulate that products must be labelled where GM has significantly changed the structure or function of the food, or if it has health implications such as the introduction of allergens.

As a result, there is no mandatory requirement for the labelling of all GM foods. Two of the three interviewees mentioned a campaign run by Greenpeace, to have all GM foods labelled, and company shareholders had also proposed that GM products be labelled. However, interviewees stated that the Food and Drug Administration is better qualified to make such judgements regarding the sale and labelling of GM foods.

Non-GM Products

The American companies tended not to have a policy regarding the sale of non-GM products sourced from a country that uses GM. This would be of no issue.

Own-Label Products

Companies tended not to know whether own-label products were GM, and once again used the Food and Drug Administration regulations as their guide.

Purchase Change

Interviewees were unable to answer questions regarding purchase change.

The New Zealand Environment

Once again, interviewees viewed New Zealand as a source of quality products. They did not see this opinion changing, should New Zealand introduce the use of GM.

ALBERTSONS

GM Products

As a general policy, Albertsons follows the Food and Drug Administration labelling policy, whereby labels must be applied to products where GM has significantly changed the structure or function of the food, or if it introduces allergens. As a result, this policy does not cover all GM foods.

Albertsons' policy does not require that the company know if products are genetically modified. Despite calls from shareholders to label all GM foods, Albertsons voted against the proposal.

> *"The Food and Drug Administration and other regulatory authorities charged with protecting the health and safety of the public and the environment are the proper entities to evaluate and make judgements about the labelling and sale of genetically engineered foods"* (Proxy Statement 2002).

Non-GM Products

Albertsons has no policy on the purchase of non-GM products from a country which uses GM for other purposes.

Own-Label Products

The interviewee stated that the company would not know whether own-label products were genetically modified or not.

The New Zealand Environment

The person interviewed was not familiar with any views that had been formed by the company on the New Zealand environment. He did say however, that New Zealand's use of GM would not affect their view of New Zealand, provided that GM products were managed in accordance with company policy.

KROGER

GM Products

Kroger does stock GM foods, and does not ask suppliers whether their products are genetically modified, as *"there is no way to know"*. Their corporate position is that:

> *"… consumers have a basic right to know the relevant information about the product they buy, including information about genetically modified foods, or foods containing genetically modified ingredients."*

However, Kroger does not label all GM foods. Kroger complies with all Food and Drug Administration labelling requirements, which state that GM foods must be labelled if the food has been significantly changed from its traditional form. However, despite calls from shareholders to label all GM foods, Kroger has voted against such a proposal, as:

> *"… we are neither qualified nor entitled to establish food safety regulations and labelling requirements."* (Proxy Statement 2001)

Kroger maintains that the Food and Drug Administration have endorsed the use of GM, and are far more able to make judgements about the sale and labelling of GM food.

SAFEWAY

GM Products

Safeway does not have a policy in which it states that it will or will not accept GM foods, as:

> *"GM food ingredients … are so much in the food production system, that we don't distinguish between the two of them."*

The company is reliant on the Food and Drug Administration to be their guide as to the safety of food products, and the labelling and sale of GM foods. The interviewee said that they had not set policy on a number of GM issues, as GM is not an important issue to their customers.

Non-GM Products

Purchasing a non-GM product from a country using GM in other ways, would be of no issue to Kroger.

Own-Label Products

Once again, the Food and Drug Administration would be their guide in stocking any GM products, or non-GM products from countries using GM, to sell under their own-label.

The New Zealand Environment

The interviewee expressed that New Zealand was a source of good quality products, and didn't think that this opinion would change should New Zealand use GM.

* * * * *

Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 5
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

Effects of GMO release on market perceptions of New Zealand's environment: Christchurch case study of international visitors

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March 2002

Introduction

In this brief report we outline the core results from an interview survey of 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. Results are presented in the order of the questions asked.

Results

Questions on relative image of the environment

Question 1: "I'll read out the names of some countries. Would you please answer by saying whether your image of their environment was…

	"Very good - among the best" %	"Good - above average" %	"Average " %	"Not good - below average" %	" Bad - among the worst" %	No Image %
Mexico		2	19	32	18	28
Switzerland	54	41				5
Thailand	2	11	31	28	8	20
New Zealand	52	47	1			
Argentina		2	32	28	6	32
Australia	18	57	24			1
South Africa	1	17	23	18	3	38
Canada	52	43	2			3
Netherlands	14	26	36	3		22
China		5	16	22	14	43
United States	9	20	56	13	1	1
United Kingdom	3	22	56	17		2
Japan	3	18	40	11		28

- 54 per cent of respondents rated Switzerland as “very good-among the best,” followed by New Zealand and Canada at 52 percent
- 57 per cent of respondents rated Australia as “good – above average” ratings. Switzerland, New Zealand and Canada also rate highly in this category 41: 47: 43 per cent respectively
- 56 per cent of respondents rated the United States and United Kingdom as “average”
- 32 per cent of respondents rated Mexico as “not good.” 28 percent rated Thailand and Argentina as “not good”
- 18 per cent of respondents rated Mexico as “bad - among the worst.” 14 per cent rated China as “not good”
- 43 per cent of respondents had “no image” of China, 38 per cent had no image of South Africa and 32 per cent had “no image” of Argentina

Question 2: "Suppose New Zealand was one of two or three countries that used genetic technology to control local pests such as rats or wasps. For example, a gene which caused them to breed less often was put into a number of rats or wasps. These are then released to mix with those in the wild so that the gene is passed around."

(a) Would your image of that country's environment get better, stay the same, or get worse?

	Frequency	Percent
Get a lot worse	2	2
Get a little worse	20	21
Stay the same	48	52
Get a little better	7	8
Get a lot better	4	4
Don't know/can't say	12	13
Total	93	100

Can you say why?	**Frequency**
Image would get better with GM pest control	
Pest reduction is essential, don't like pests	5
In favour of progress or technology	3
GE not a problem	1
Image would get worse with GM pest control	
Don't like the idea of GMO pest control	6
GM is bad	2
GM is unpredictable	2
Concerned about effects on nature	3
Use natural pest control	1
Concern for other animals	1
Try to control one species you don't know the effect on other species - food chain - cycle of life	1
Fear the creation of super bugs	1
Dislike human involvement in nature	1

Note: the numbers in the 'Can you say why?' tables do not match the frequencies in the corresponding table because not all respondents gave a reason for their opinion.

Question 3: "Suppose New Zealand was one of two or three countries to use a strain of rye grass modified by genetic technology. The gene of the grass would be changed to increase its food value. Farmers would plant fields of the modified rye grass to feed their livestock."

(a) Would your image of that country's environment get better, stay the same, or get worse?

	Frequency	Percent
Get a lot worse	3	3
Get a little worse	19	20
Stay the same	52	56
get a little better	3	3
get a lot better	3	3
don't know/can't say	13	14
Total	93	100

Can you say why?	**Frequency**
Image would get better with GMO rye grass	
Improved quality of meat for consumer	2
Pro Technology	1
Image would get worse with GMO rye grass	
Don't like the idea of GM	3
GM is unpredictable	2
Fear the creation of super weeds / spread of GM seeds	2
Need to be careful with GM - keep it in the lab	1
GMO's are bad. I hate them	1
GMO animal feed is unnecessary, there is plenty of feed now	1

Question 4: "Suppose New Zealand was one of two or three countries to use a virus whose genes have been changed in such a way that protects a person against a contagious disease such as Hepatitis or Meningitis. The modified virus, once in the person's bloodstream, would remain there, attacking the disease virus if or when the person got infected."

(a) Would your image of that country's environment get better, stay the same, or get worse?

	Frequency	Percent
get a lot worse	14	15
get a little worse	17	18
stay the same	37	40
get a little better	9	10
get a lot better	4	4
don't know/can't say	12	13
Total	93	100

Can you say why?	Frequency
Image would get better with GMO vaccine	
Prevent illness / Save Lives	8
Shouldn't fear progress	1
Image would get worse with GMO vaccine	
Dangerous	4
"Not a good idea"	2
Interfere with nature / Unnatural	6
Unpredictable (super virus)	5
Don't modify people ("Not in my body thanks")	3

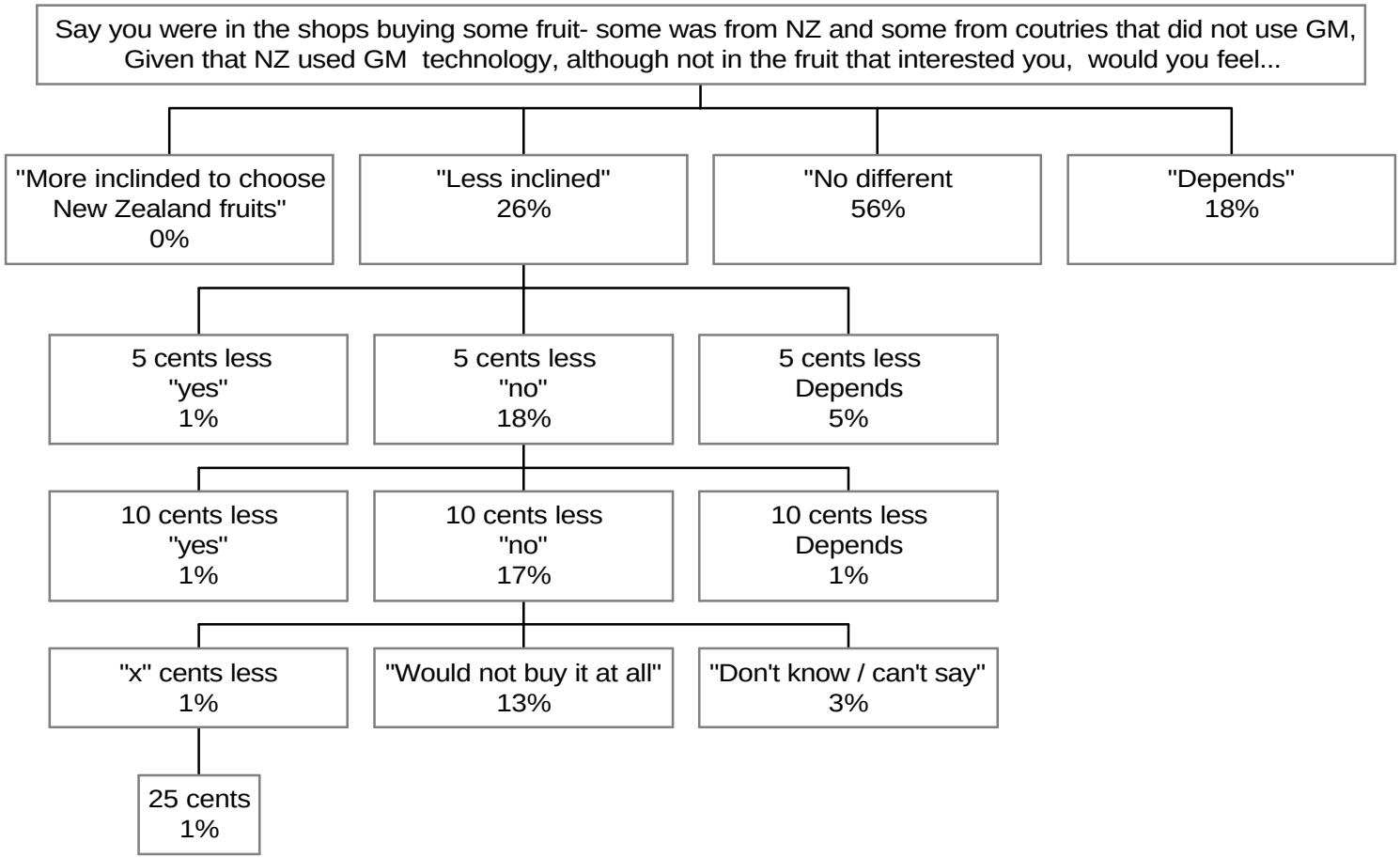
Question 5: "Suppose New Zealand was one of two or three countries not to use genetically modified organisms in production, nor release GM organisms into the environment."

(a) "Would your image of that country's environment get better, stay the same or get worse

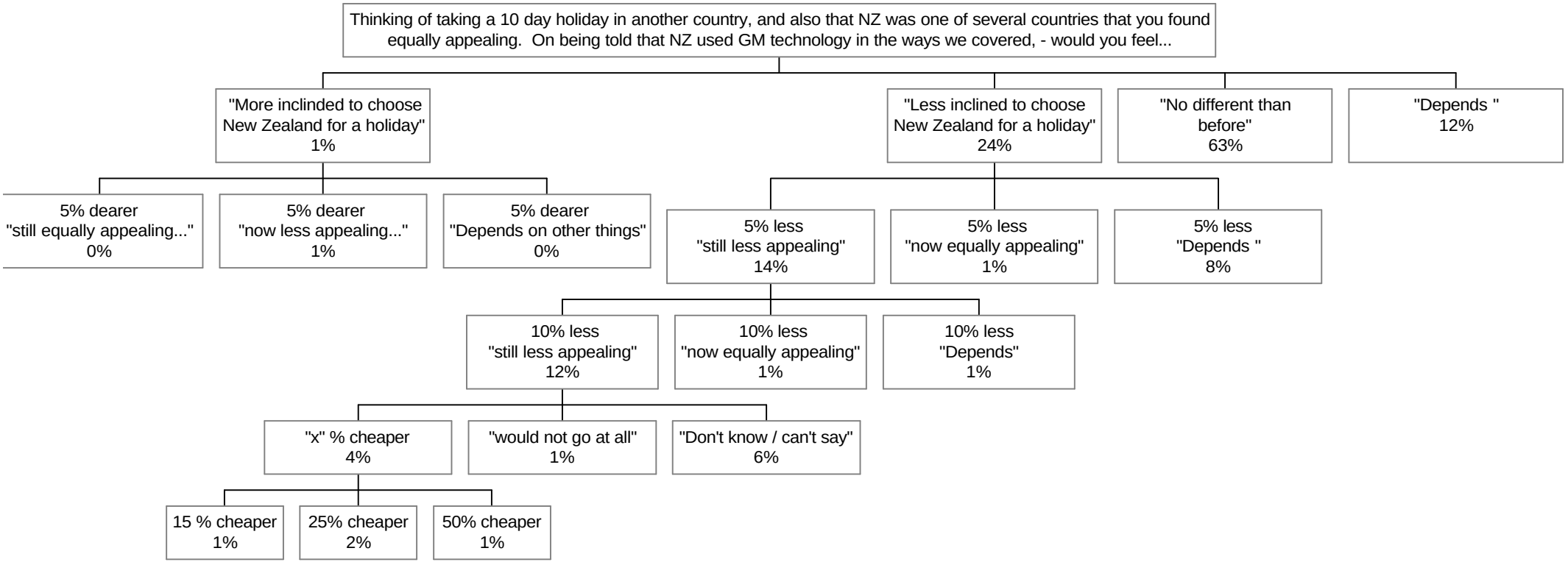
	Frequency	Percent
get a little worse	2	2
stay the same	44	47
get a little better	25	27
get a lot better	17	18
don't know/can't say	5	5
Total	93	100

Can you say why?	Frequency
Image would get worse if NZ didn't use GMO	
Need to be progressive (overcome techno fear)	1
Image would get better if NZ didn't use GMO	
Clean and green (safe, haven, pretty)	6
Stay natural	3
Unpredictable GMO	3
Good no GMO	7

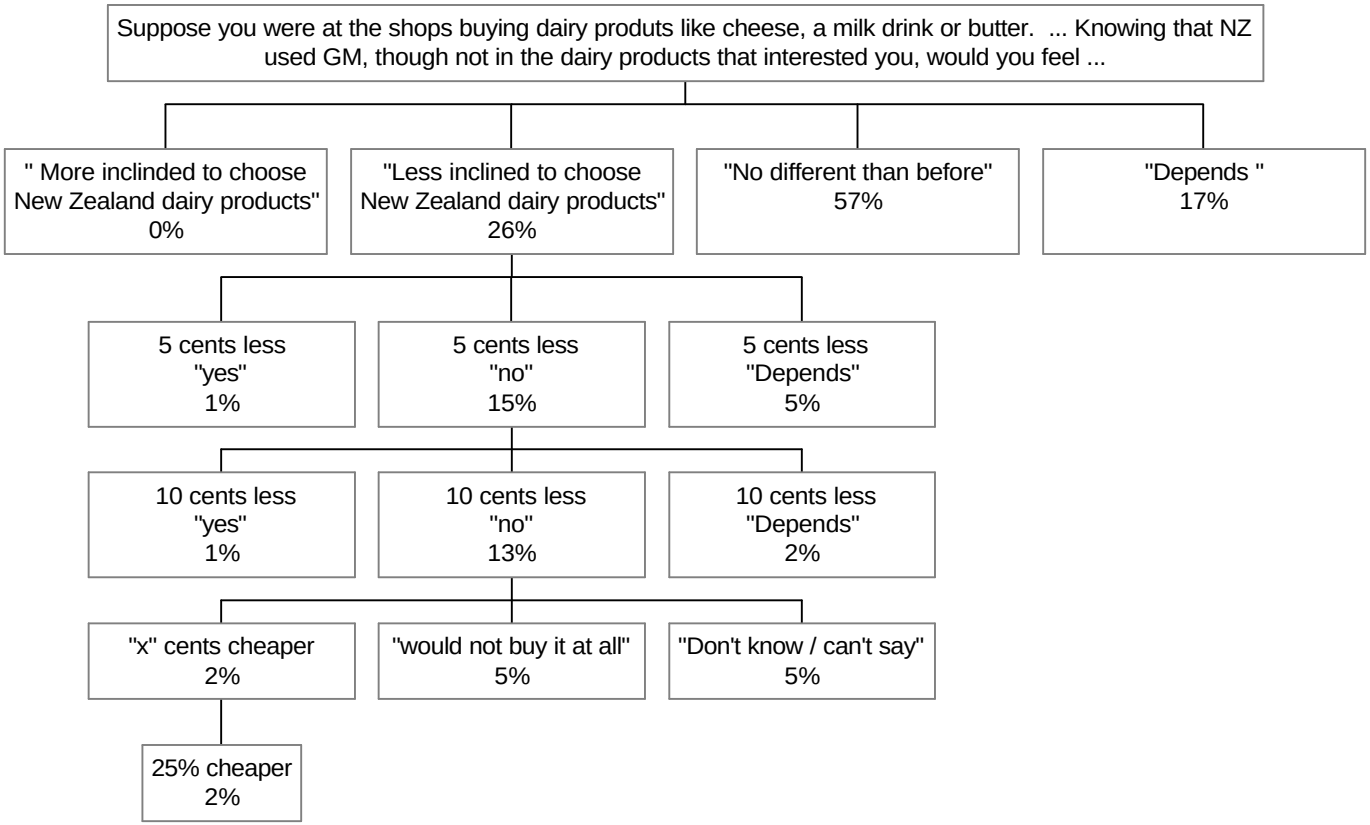
Question 6


Say you were in the shops buying some fruit- some was from NZ and some from coutries that did not use GM, Given that NZ used GM technology, although not in the fruit that interested you, would you feel...
"More inclinded to choose New Zealand fruits" 0%
"Less inclined" 26%
"No different 56%
"Depends" 18%
5 cents less "yes" 1%
5 cents less "no" 18%
5 cents less Depends 5%
10 cents less "yes" 1%
10 cents less "no" 17%
10 cents less Depends 1%
"x" cents less 1%
"Would not buy it at all" 13%
"Don't know / can't say" 3%
25 cents 1%

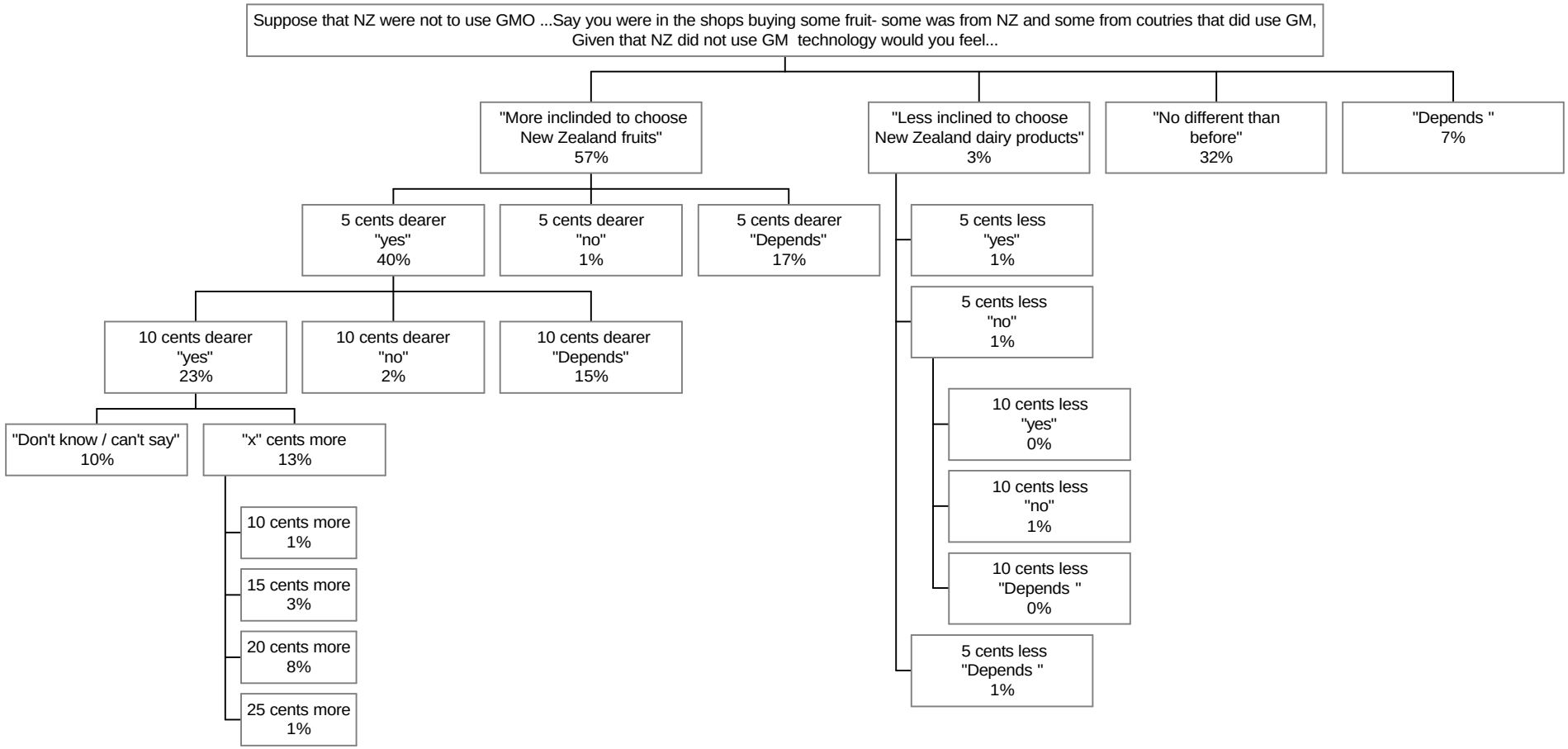
Question 7


Thinking of taking a 10 day holiday in another country, and also that NZ was one of several countries that you found equally appealing. On being told that NZ used GM technology in the ways we covered, - would you feel...
"More inclinded to choose New Zealand for a holiday" 1%
"Less inclined to choose New Zealand for a holiday" 24%
"No different than before" 63%
"Depends " 12%
5% dearer "still equally appealing..." 0%
5% dearer "now less appealing..." 1%
5% dearer "Depends on other things" 0%
5% less "still less appealing" 14%
5% less "now equally appealing" 1%
5% less "Depends " 8%
10% less "still less appealing" 12%
10% less "now equally appealing" 1%
10% less "Depends" 1%
"x" % cheaper 4%
"would not go at all" 1%
"Don't know / can't say" 6%
15 % cheaper 1%
25% cheaper 2%
50% cheaper 1%

Question 8


Suppose you were at the shops buying dairy produts like cheese, a milk drink or butter. ... Knowing that NZ used GM, though not in the dairy products that interested you, would you feel ...
" More inclinded to choose New Zealand dairy products" 0%
"Less inclined to choose New Zealand dairy products" 26%
"No different than before" 57%
"Depends " 17%
5 cents less "yes" 1%
5 cents less "no" 15%
5 cents less "Depends" 5%
10 cents less "yes" 1%
10 cents less "no" 13%
10 cents less "Depends" 2%
"x" cents cheaper 2%
"would not buy it at all" 5%
"Don't know / can't say" 5%
25% cheaper 2%

Question 9


Suppose that NZ were not to use GMO ...Say you were in the shops buying some fruit- some was from NZ and some from coutries that did use GM, Given that NZ did not use GM technology would you feel...
"More inclinded to choose New Zealand fruits" 57%
"Less inclined to choose New Zealand dairy products" 3%
"No different than before" 32%
"Depends " 7%
5 cents dearer "yes" 40%
5 cents dearer "no" 1%
5 cents dearer "Depends" 17%
5 cents less "yes" 1%
5 cents less "no" 1%
10 cents dearer "yes" 23%
10 cents dearer "no" 2%
10 cents dearer "Depends" 15%
10 cents less "yes" 0%
10 cents less "no" 1%
10 cents less "Depends " 0%
"Don't know / can't say" 10%
"x" cents more 13%
5 cents less "Depends " 1%
10 cents more 1%
15 cents more 3%
20 cents more 8%
25 cents more 1%

Question 10

Gender		
	Frequency	Percent
Female	38	41
Male	55	59
Total	93	100

Home country		
	Frequency	Percent
Australia	17	18
Japan	4	4
Korea	2	2
Other Asia	4	4
United Kingdom	27	29
Other Europe	12	13
USA	20	22
Other America	7	8
Total	93	100

Age Category		
	Frequency	Percent
18-29	36	39
30-39	18	19
40-49	14	15
50-59	12	13
60-69	8	9
Over 70	5	5
Total	93	100

Report to

MINISTRY FOR THE ENVIRONMENT

APPENDIX 6

TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

Economy-wide modelling experiments

March 2003

BERL ref#4173

Contents

1 INTRODUCTION

This appendix details the model experiments undertaken using a computable general equilibrium model of the New Zealand economy exploring several scenarios surrounding the release of genetically modified organisms in New Zealand.

The sections below are arranged as follows

- section 2 : outlining the model structure
- section 3 : containing detail of the industry, export commodity, occupation classifications within model
- section 4 : describing the experiments undertaken - ie the input assumptions
- section 5 : listing the 'closure' assumptions and parameter detail
- section 6 : presenting the results of each of the experiments

2 MODEL OUTLINE

This study uses a general equilibrium model to provide measures of the potential economic impacts of various scenarios arising from the release or otherwise of GMOs.

General equilibrium models are a well-established and internationally accepted tool in the field of economic analyses and are ideally suited to the type of analysis undertaken here - noting, in particular, the distinction between comparative scenario analyses and that of 'forecasting'.

These models enable a rigorous analysis of particular events from an economic viewpoint. The fundamental premise underlying the relationships within the model is that of the market mechanism. Indeed the model is in essence an attempt to 'mimic' the market processes, the behaviour of market participants and their responses to a proposed event or combination of events.

The market mechanism focuses on demands for and supplies of products and resources - and the associated buyers and sellers. In response to 'an event' the market adjustment process involves buyers and sellers altering their demands or supplies. Productive resources are consequently 're-allocated' such that the maximum net economic benefit is obtained by the market participants. In this context economic benefit relates to industries operating at least-cost methods of production and consumers maximising their satisfaction[1] while remaining within the constraints of their budget (income).

The general equilibrium model is an economic tool used to simulate this process and produce empirical estimates of the changes in each market (ie the price and quantities produced and consumed of commodities) as a result of a specified 'event'.

Given this market viewpoint, a model of an open (to external trade) economy such as New Zealand's will unambiguously yield positive net benefits (at the total economy-wide level) from any of the following individual events :

- an improvement in productive efficiency - that is, higher productivity - viz, the ability to produce output using less inputs on a per-unit basis; whether the inputs be labour, capital equipment and/or raw materials.
- an improvement in cost efficiency - that is, a reduction in the per-unit costs of production.
- a favourable change in the international terms of trade - that is, an increase in the world prices received for our exports relative to those paid for our imports.

[1] the economic term is 'utility'.

- an increase in productive capacity - that is, an increase in the supply of labour and/or capital equipment available to production processes.

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. This 'balancing act' 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 a good will adjust to ensure that demand for that good equals the supply of that good. ie. if demand is greater than supply then the price of the good in question will rise; if supply is greater than demand then its price will decline. A similar 'adjustment mechanism' is imposed for resources.

- at equilibrium prices there are zero 'pure-profits' to New Zealand producers - in other words selling prices equate to costs of production (the latter incorporating a 'normal' rental rate on capital employed).

- 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 is becomes cheaper that 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. Summary details of these classifications are provided in section 3.

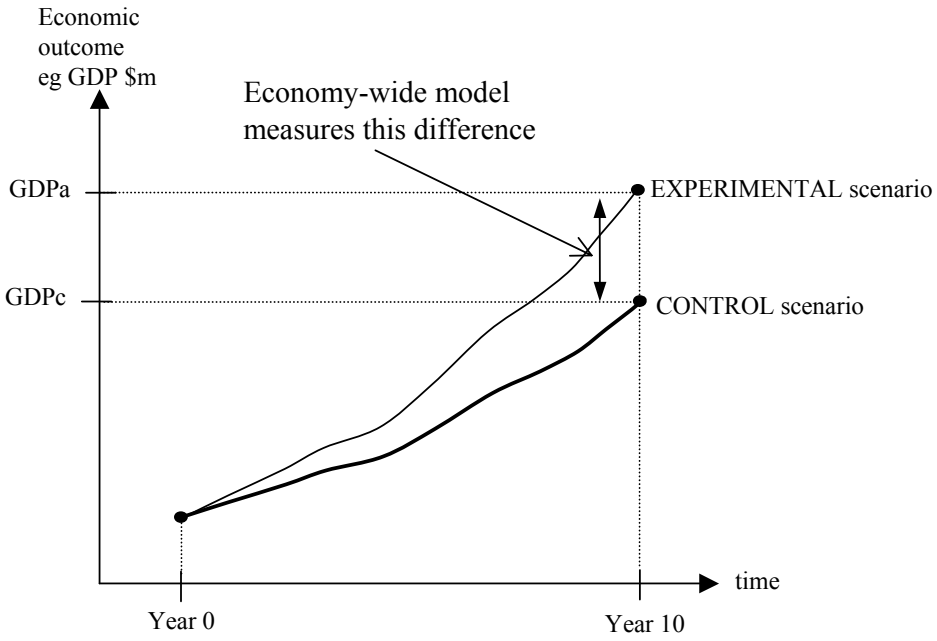
It should be noted that the ability to adjust resource use is limited. This limitation is imposed through constraints mimicking the technological processes within each of the 49 industries.

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.

The results presented in section 6 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 the figure below.

Figure 2.1 Interpreting the economy-wide model experiment results



The model measures the difference between, for example, the level of GDP ten years hence in the control scenario and the level of GDP ten 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[2] ten years from the initial impact.

[2] or the percentage change in various other economic measures - for example: employment, exports, imports, consumption spending.

3 CLASSIFICATIONS

The detail of the classifications incorporated in the model are tabulated below.

3.1 Industry classification

CGE #	Industry code	ANZSIC	Description
1	HFRG	A011	Horticulture and fruit growing
2	MLVC	A0121, A0122, A01591	Mixed livestock and cropping
3	SHBF	A0123-A0125	Sheep and beef cattle farming
4	DAIF	A013	Dairy cattle farming
5	OAGR	rest A01, A02	Other farming and services to agr, hunting & trapping
6	LOGG	A03	Forestry & logging
7	FISH	A04	Commercial fishing
8	COAL	B11	Coal mining
9	OILG	B12, B1511, B1512	Oil & gas extraction and exploration
10	OMIN	B13, B14, B1514, B1520	Other mining & quarrying and services to mining
11	MEAT	C2111	Meat processing
12	DAIR	C212	Dairy product manufacturing
13	OFOD	rest C21	Other food processing & mfg
14	TCFL	C22	Textiles, clothing, footwear & leather mfg
15	WOOD	C231, C232	Log sawmilling, timber dressing & oth wood product mfg
16	PAPR	C233, C239	Paper and paper product mfg
17	PPRM	C24	Printing, publishing & recorded media
18	PETR	C251, C252	Petroleum
19	CHEM	C253, C254	Chemical and chemical product mfg
20	RBPL	C255, C256	Rubber and plastic product mfg
21	NMMP	C26	Non-metallic mineral product mfg
22	BASM	C271-C273	Basic metal manufacturing
23	FABM	C274-C276	Structural, sheet and fab metal prod mfg
24	MACH	C28	Machinery and equipment mfg
25	OMFG	C29	Other manufacturing
26	EGEN	D361pt	Electricity generation
27	EDIS	D361pt	Electricity transmission & supply
28	GASS	D362	Gas supply
29	WATS	D3701	Water supply
30	BLDG	E	Construction
31	TRDE	F, G	Wholesale & retail trade
32	ACCR	H57	Accommodation, cafes & restaurants
33	ROAD	I61, I661	Road transport
34	WRAI	I62, I63, I662	Water and rail transport
35	AIRS	I64, I65, I663,I664, I67	Air transport, services to transport, storage

CGE #	Industry code	ANZSIC	Description
36	COMM	J71	Communication services
37	FIIN	K	Finance and insurance
38	OWND	L771190pt	Ownership of owner-occupied dwellings
39	OPRS	rest L77	Other property services
40	SCIT	L781, L782	Scientific research & technical services
41	COMP	L783	Computer services
42	LAOB	L784-L786 (xL7865-66)	Legal, accounting & other business services
43	GOVD	M, Q9633	Govt administration & defence
44	SCHL	N84 (xN843) O871	Pre-school, primary, secondary & other education
45	OEDU	N843	Post-school education
46	HOSP	O861, O872	Hospitals, nursing homes, aged accom & other comm care
47	OHLT	rest O86	Medical, dental and other health services
48	CULT	P	Cultural and recreational services
49	PERS	D3702, L7865-66, Q (excl Q9633)	Personal and other services, pest control and cleaning services, waste disposal & sewerage svs

3.2 Export commodities

CGE #	Export code	Description
1	DAIR	Dairy
2	MEAT	Meat
3	WOOL	Wool
4	HORT	Horticultural products
5	FISH	Fish
6	OFBT	Other food products
7	TEXT	Textiles
8	LOGS	Logs
9	WOOD	Wood
10	PAPR	Paper
11	OILL	Oil
12	CHEM	Chemicals
13	COAL	Coal
14	MING	Other mining products
15	CERA	Ceramics
16	BASM	Basic metal products
17	FABM	Fabricated metal products and machinery
18	OMFG	Other manufactured products
19	TOUR	Tourism services
20	TNSP	Freight and transport services
21	EDUC	Education services
22	OSVS	Other services

3.3 Classification of labour occupations

CGE #	Occn code	NZSCO	Description
1	LEGA	11	Legislators and administrators
2	CORP	12	Corporate managers
3	SCIP	211, 212, 221	Physicists, chemists, mathematicians and related professionals, life science professionals
4	COMP	213	Computing professionals
5	AREN	214	Architects, engineers and related professionals
6	HLTP	222, 223	Health professionals, nursing & midwifery
7	TETP	231	Tertiary teaching professionals
8	OTEP	232-235	Other teaching professionals
9	BUSP	241	Business professionals
10	LEGP	242	Legal professionals
11	OTHP	243-245	Other professionals
12	SCIT	311, 321	Physical science and engineering technicians, life science technicians and related
13	CMEC	312	Computer equipment controllers
14	OPEC	313	Optical and electronic equipment controllers
15	OCTS	314	Ship and aircraft controllers and technicians
16	HLAP	322, 323	Health associate professionals
17	FSAP	331, 332	Finance, sales and administrative associate professionals
18	GVAP	333, 334, 335	Government and social work associate professionals, careers and employment advisors
19	OTAP	315, 337, 338	Safety and health inspectors, environmental protection and other associate professionals
20	WAES	336	Writers, artists, entertainment and sports associate professionals
21	OFCK	41	Office clerks
22	CSCK	42	Customer services clerks
23	TRAV	511	Travel attendants and guides
24	REST	512	Housekeeping and restaurant services workers
25	POCW	513, 514	Personal care and other personal service workers
26	PRSW	515	Protective services workers
27	SALE	52	Salespersons, demonstrators and models
28	FARM	611-612	Farmers, growers and animal producers
29	FRST	613	Forestry and related workers
30	FISH	614	Fishery workers, hunters and trappers
31	BDTW	71	Building trades workers
32	MMTW	72	Metal and machinery trades workers
33	PRTW	73	Precision trades workers
34	OCTW	74	Other craft and related trades workers
35	IPMO	81, 82	Industrial plant operators, stationary machine operators
36	RAIL	831, 834	Railway engine drivers, ships deck crews and related workers
37	MOVD	832	Motor vehicle drivers
38	AGEO	833	Agricultural, earthmoving and other materials handling equipment operators
39	BLRW	84	Building and related workers
40	LBSW	91	Labourers and related elementary service workers

4 INPUT ASSUMPTIONS

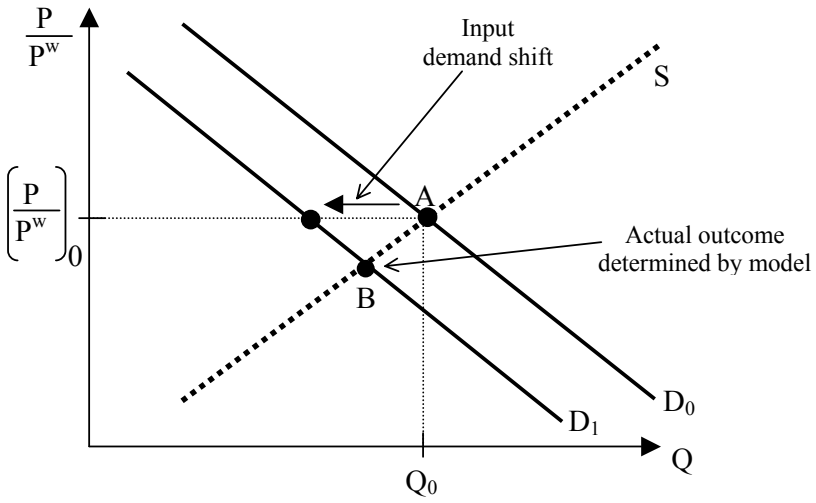
The tables in this section list the input assumptions adopted for each of the model experiments undertaken. In essence, they comprise a combination or combinations of export demand shifts, changes in the world price of competing exports and productivity changes outlined as follows.

4.1 Export demand curve shift

- a horizontal shift in the demand curve for NZ dairy exports
- a horizontal shift in the demand curve for NZ meat exports
- a horizontal shift in the demand curve for NZ horticulture exports
- a horizontal shift in the demand curve for NZ tourism exports

An example is illustrated in Figure 4.1below.

Figure 4.1 A reduction in export demand



where P = price of NZ export commodity

P^w = price of competing export commodity produced elsewhere

D_0 = foreign demand curve facing NZ exporters in *Control*

Q_0 = the level of NZ export volumes in *Control*

D_1 = foreign demand curve facing NZ exporters in *Experiment*

As depicted above, for a given demand curve shift, the actual outcome (ie the movement from point A to point B) is determined by the model. The modelled outcome is primarily dependent on the change in price competitiveness of New Zealand-made

products vis-à-vis products made elsewhere (ie represented by the relative price variable P/P^w) and the elasticity of the demand curve.

Note that the outcome depicted in Figure 4.1 above, illustrates a scenario where the input assumptions being imposed comprise **solely** reductions in demand for New Zealand products **alone**. Where additional input assumptions are also imposed (for example, productivity changes), then the picture would need to be further modified.

4.1.1 Demand shifts from the survey responses

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 may continue to purchase New Zealand products, there were some who would only buy if the price was lower than before and there were others who remained prepared to buy at a higher price.

The average 'willing to pay' price was calculated as an average of the influences deriving from the behavioural responses of these two groups of consumers. However, 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'.

This is reflected the calculated 'post-GMO' average prices for (again, remembering that these are only calculated for those that 'remained in the market' as listed in Table 4.1. Note that, as a base, the 'pre-GMO' average 'willing to pay' price was set at 100.

Table 4.1 Post-GMO average 'willing to pay' price of consumers exhibiting non-zero demand

	NRB survey			Lincoln survey
	Australian consumers	UK consumers	US consumers	
fruit purchase	99.6	99.2	100.5	97.6
dairy purchase	100.9	100.3	100.5	96.4
holiday purchase	100.7	99.4	99.9	96.1

Note: based on pre-GMO average 'willing to pay' price = 100.

Reiterating, these numbers indicate that - 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 indicate that the 'horizontal' shift of the demand curve facing New Zealand exporters (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 4.2 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 4.2 Calculating the horizontal shift of the demand curve facing New Zealand exporters

	NRB survey data				
	AUS	UKM	USA	weighted avge shift from NRB	**shift from Lincoln survey**
fruit purchase					
less inclined to buy and price change makes no difference (%)	27	30	20		13
trade weights	0.2858	0.3717	0.3425		na
weighted shifts (%)	7.7	11.2	6.9	25.7	13
dairy purchase					
less inclined to buy and price change makes no difference (%)	21	29	21		5
trade weights	0.1037	0.2834	0.6129		na
weighted shifts (%)	2.2	8.2	12.9	23.3	5
holiday purchase					
less inclined to buy and price change makes no difference (%)	9	6	5		1
trade weights	0.3855	0.2972	0.3173		na
weighted shifts (%)	3.5	1.8	1.6	6.8	1

From the NRB survey for example, an average of 25.7% of respondents across the three countries 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 are then combined with the numbers from the Lincoln survey using 80%:20% proportions respectively[3]. 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 fact that a significant component of New Zealand dairy and meat exports in particular are not sold directly to consumers as identifiably New Zealand-made products but are, rather, ingredients or component inputs into other commodities. It is estimated that the 40% of New Zealand's dairy exports and 45% of New Zealand's meat exports above are 'open to such direct consumer' responses. As such, the above shifts were translated into representing the horizontal shift in demand curves upon the introduction of GMOs, as listed in Table 4.3.

Table 4.3 Assumed demand curve shifts (horizontal) with GMO release

% shift in demand curve	% open to consumer response	for CRP and PST sims		for HUM sims	
		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 bio-control GMO
HUM = scenarios involving the release of a human medicine GMO

No GMO scenarios

In the case of no GMOs in New Zealand, the average prices willing to pay of those remaining in the market were significantly above those of the base case, as listed in Table 4.4.

Table 4.4 No-GMO average 'willing to pay' price of consumers exhibiting non-zero demand

	NRB survey			Lincoln survey
	Australian consumers	UK consumers	US consumers	
no GMOs	108.5	110.6	107.0	109.9

Note: average 'willing to pay' price in base case = 100.

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

These calculations indicate an upward shift of the demand curves facing New Zealand exporters in these markets. The corresponding horizontal shifts in these demand curves were calculated using an average demand curve elasticity of 4.0[4]. The resulting calculations from the NRB survey were weighted (using trade weights as above), providing an implied horizontal demand shift of the order of 33.0%. The Lincoln survey information implied a shift of the order of 39.6%.

These two figures 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 consumer response, as per Table 4.5 below.

Table 4.5 Shift in demand curve facing New Zealand exporters given no GMOs scenario

% shift in export demand curve	% open to consumer response	for NOG sims	
		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

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

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 expressed attitudes towards human medicine GMOs on the one hand and pest control and crop GMOs on the other. This difference is summarised in **Error! Reference source not found.** and Table 4.7.

[4] as per sub-section **Error! Reference source not found.**.

Table 4.6Effect on New Zealand's image if there was a release of GMO : NRB survey

	pest control GMO (%) (1)	crop GMO (%) (2)	human medicine GMO (%) (3)
get better	25.3	26.0	38.7
get worse	32.3	36.3	18.7

Table 4.7 Effect on New Zealand's image if there was a release of a GMO : Lincoln survey

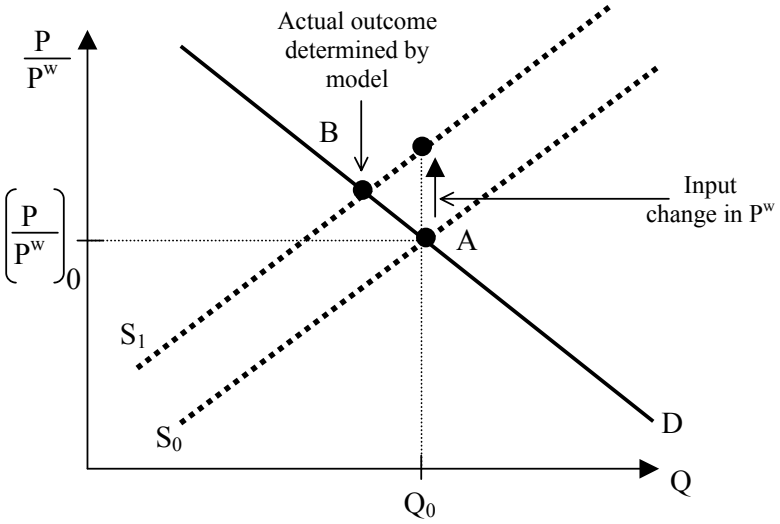
	pest control GMO (%) (1)	crop GMO (%) (2)	human medicine GMO (%) (3)
get better	12	6	14
get worse	23	23	33

4.2 Change in the world price of competing exports

Here the input change is imposed on the variable P^W. This can be thought of as the equivalent of an **initial** vertical shift in the supply curve. In particular, where an assumed fall in P^W is imposed, the relativity between P and P^W deteriorates against New Zealand producers. Or, in other words, New Zealand-made products become less price competitive on foreign markets.

As a result, New Zealand producers need to either achieve cost savings enabling them to reduce P (and so move back along their demand curve towards the Control Q_0) and/or experience a fall in volumes achieved. The extent of the **secondary** mitigating change in production costs (if any) is determined by the model as a result of the numerous in 'balancing acts' outlined earlier consistent with the market-clearing general equilibrium criteria. The actual outcome is represented by the movement from point A to point B.

Figure 4.2 An reduction in the price of competing export products



where P = price of NZ export commodity

P^w = price of competing export commodity produced elsewhere

S_0 = effective supply curve for NZ exports in *Control*

S_1 = impact of change in P^w on NZ export supply curve in *Experiment*

Q_0 = the level of NZ export volumes in *Control*

Again, note that the outcome depicted in Figure 4.2 above, illustrates a scenario where the input assumptions being imposed comprise **solely** reductions in the price of competing export products **alone**. Where additional input assumptions are also imposed (for example, productivity changes), then the picture would need to be further modified.

4.3 Productivity change

- a change in the productivity of the New Zealand pastoral agriculture industry (ie industries 2, 3 and 4 above - namely: mixed livestock & cropping, sheep & beef cattle farming and dairy cattle farming.

This is input as a reduction in the per-unit requirements of labour and capital by these three industries. In essence this can be viewed as an inward shift in the isoquant maps facing these producer sectors.

In turn, this - in the first instance - reduces the per-unit costs of production for New Zealand exports originating from these industries and so flows through - again in the

first instance - to a reduction in the variable P.[5] This 'flow through' being consistent with the general equilibrium criterion of zero 'pure-profits', as described earlier.

This effect implies an improvement in the price competitiveness of New Zealand-made products (ie a fall in the variable P/P^w) and so increases New Zealand's export volumes.

4.4 Model experiment specifications

The following tables list the model experiments undertaken and their associated input assumptions (numerical), along with brief explanatory comments.

[5] In effect, this could be pictured as a 'downwards' shift in the NZ export supply curve.

Table 4.8 Scenario input specifications : a crop GMO

eg rye grass

label	GMO induced productivity improvement	uptake of GMO within pastoral agric	maintained for 'x' years ?	total prod'y improvement in pastoral agric	demand shift on dairy exports	demand shift on meat exports	demand shift on hortic. exports	demand shift on tourism exports	comment
#1	0%pa	50%	10yrs	0%	-7.8%	-8.8%	-23.2%	-5.7%	GMO provides no boost to agric (or negated by seed/segregation and other costs) but some non-zero uptake, so demand effect remains
#2	2.5%pa	50%	5 yrs	6.4%	-7.8%	-8.8%	-23.2%	-5.7%	'one-off' enhancement to processes; RoW adopts and catches up in 5yrs
#3	2.5%pa	50%	10yrs	13.2%	-7.8%	-8.8%	-23.2%	-5.7%	'series' of enhancements such that NZ maintains relative gain for 10 yrs
#3a	4.0%pa	75%	10yrs	34.4%	-7.8%	-8.8%	-23.2%	-5.7%	= #3 but with greater productivity boost, from GMO and, hence, higher uptake
#3b	2.5%pa	50%	10yrs	13.2%	-11.7	-13.2%	-34.8%	-8.6%	= #3 but with greater (ie 50% more) demand shift against all (GM and non-GM) NZ produce and tourism
#3c	2.5%pa	50%	10yrs	13.2%	-3.9%	-4.4%	-11.6%	-2.9%	= #3 but with reduced (ie 50% less) demand shift against NZ produce and tourism
#6	2.5%pa	50%	10yrs	13.2%	0%	0%	0%	0%	= #3 but with no demand shift (for or against)

Table 4.9 Scenario input specifications : a pest control GMO

eg. possum control

label	GMO induced productivity improvement	'uptake' of GMO	maintained	total prod'y improvement in pastoral agric	demand shift on dairy exports	demand shift on meat exports	demand shift on hortic. exports	demand shift on tourism exports	comment
#4	6%	100%	10 yrs	6%	-7.8%	-8.8%	-23.2%	-5.7%	reduction by half in the incidence of bovine Tb
#4a	6%	100%	10 yrs	6%	-11.7%	-13.2%	-34.8%	-8.6%	= #4 but with greater (ie 50% more) demand shift against all NZ produce and tourism
#4b	6%	100%	10yrs	6%	0%	0%	0%	0%	= #4 but with no demand shift against all NZ produce and tourism
#4c	6%	100%	10 yrs	6%	-3.9%	-4.4%	-11.6%	-2.9%	= #4 but with reduced (ie 50% less) demand shift against NZ produce and tourism
#5	12%	100%	10 yrs	12%	-7.8%	-8.8%	-23.2%	-5.7%	= #4 but with GMO fully successful in reducing incidence of bovine Tb

Table 4.10 Scenario input specifications : no GMOs in NZ

ie NZ refrains from the use of GM in agriculture, food and pharmaceuticals, so there is no GM production in NZ

label	Change in world price of dairy, meat & hortic	demand shift on hortic exports	demand shift on dairy exports	demand shift on meat exports	demand shift on tourism exports	comment
#7	0%	34.3%	13.7%	15.4%	34.3%	= demand impact from no GMOs in NZ and with zero productivity gains in RoW from their GM adoption
#8	-6.4%	34.3%	13.7%	15.4%	34.3%	=#7 but with moderate productivity gains in RoW from their GM adoption foregone by NZ producers
#9	-13.2%	34.3%	13.7%	15.4%	34.3%	= #7 but with productivity gains in RoW from their GM adoption foregone by NZ producers
#9a	-30%	34.3%	13.7%	15.4%	34.3%	=#9 with greater productivity gains in RoW from their GM adoption
#10	-13.2%	0%	0%	0%	0%	= RoW productivity gains as per #7 but with no demand shift
#10a	-13.2%	17.1%	6.9%	7.7%	17.1%	= #10 but with reduced demand shift (ie 50% less) to NZ produce and tourism
#10b	-13.2%	51.5%	20.6%	23.1%%	51.5%	= #10 but with larger demand shift (ie 50% more) to NZ produce and tourism
#E1	0%	51.5%	20.6%	23.1%	51.5%	extreme 1 - zero RoW productivity gains and higher demand shift
#E2	-30%	0%	0%	0%	0%	extreme 2 - greater RoW productivity gains and zero demand shift

Table 4.11 Scenario input specifications : a human medicine GMO

(eg use of a virus whose genes have been changed in such a way that protects a person against a contagious disease such as Hepatitis of Meningitis)

label	demand shift on dairy exports	demand shift on meat exports	demand shift on hortic. exports	demand shift on tourism exports	Export earnings	GM research industry	comments
#11	-3.9%	-4.4%	-11.6%	-2.9%	na	na	GMO vaccine is not produced in NZ; imported into NZ
#12	-3.9%	-4.4%	-11.6%	-2.9%	+$200m	production costs(?)	GMO vaccine is 'home-grown' and export earnings are reaped
#13	-3.9%	-4.4%	-11.6%	-2.9%	+$400m	production costs(?)	= #12 but with greater export earnings
#14	-5.9 %	-6.6%	-17.4%	-4.4%	na	na	= #11 but with greater (ie 50% more) demand shift against all NZ produce and tourism
#14a	-1%	-1%	-1%	-1%	na	na	= #14 but with smaller demand shift against all NZ produce and tourism
#14b	-2.0%	-2.2%	-5.8%	-1.5%	na	na	= #14 but with reduced (ie less 50%) demand shift against all NZ produce and tourism

5 CLOSURE AND PARAMETERS

5.1 Export elasticity parameters

The elasticities of demand facing New Zealand exporters in foreign markets adopted in the model experiments reported below are as follows:

Export code	Description	Elasticity of demand
DAIR	Dairy	-4
MEAT	Meat	-4
WOOL	Wool	-1
HORT	Horticultural products	-4
FISH	Fish	-5
OFBT	Other food products	-5
TEXT	Textiles	-5
LOGS	Logs	-5
WOOD	Wood	-5
PAPR	Paper	-5
OILL	Oil	-2
CHEM	Chemicals	-5
COAL	Coal	-2
MING	Other mining products	-5
CERA	Ceramics	-5
BASM	Basic metal products	-5
FABM	Fabricated metal products and machinery	-5
OMFG	Other manufactured products	-5
TOUR	Tourism services	-5
TNSP	Freight and transport services	-4
EDUC	Education services	-5
OSVS	Other services	-5

Note that the elasticities for dairy, meat and horticulture products are higher than in the 'standard' model, as derived from survey responses. Such higher elasticities are attributable to those that 'remain in the market' - ie. those that indicate some responsiveness to price changes. The survey responses basis for the elasticities for these four commodities is outlined in sub-section 5.1.1 below.

5.1.1 Sensitivity to price changes from survey responses

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 as a set of 15 observations[6] concerning price and demand

[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.

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, there were a total of 10% of Australian respondents who 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 5% price reduction resulted in the proportion that remained less inclined to purchase falling from 10% to 8%. This increase of 2% out of a total o10% (ie a 20% change) in the face of a 5% price change implies an elasticity of 4.

Price sensitivity of foreign consumers for horticulture

From the NRB responses to the fruit purchase question, the calculated elasticity of demand ranged from 1.9 to 7.5. The weighted average of these suggests and elasticity of 3.8. Furthermore, 9 of the 15 observations calculated elasticities in the3.0 to 4.5 range.

In addition, using only the 9 observations in response to a lower price, a weighted average elasticity of 4.3 is derived. This subset of observations is forwarded as indicating a likely response if the GMO scenarios resulted in productivity improvements (and, consequently, lower prices) arising from GMO adoption. However, this subset should not wholly drive the imposed elasticity, as the possibility of higher prices (whether it be from the lack of any GMO-induced productivity improvements, or just from the overall result of the general equilibrium market mechanism) can not be ignored.

Thus the elasticity of demand facing New Zealand exporters of horticulture commodities is set at 4.0 in the simulations below.

Price sensitivity of foreign consumer for dairy and meat

Using the set of 15 observations from NRB responses to the dairy purchase question, the calculated elasticity of demand ranged from 1.4 to 6.7. The weighted average of these suggests and elasticity of 3.9. Furthermore, 8 of the 15 observations calculated elasticities in the 3.0 to 4.5 range.

Using only the 9 observations associated with a reduction in price, suggests an elasticity of near 4.3.

Thus the elasticity of demand facing New Zealand exporters of dairy and meat products is set at 4.0 in the simulations below.

Price sensitivity for foreign consumer for tourism

Using the set of 15 observations from NRB responses to the holiday purchase question, the calculated elasticity of demand ranged from 1.4 to 6.7. The weighted average of these suggests and elasticity of 3.6. Furthermore, 10 of these 15 observations were in the 2.5 to 5.0 range.

Using only the 9 observations relating to lower price of holidays, suggests an elasticity of 4.6.

Thus the elasticity of demand facing New Zealand exporters of tourism services is set at 4.0 in the simulations below.

Table 5.1 Export demand sensitivity (elasticity)

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

5.2 Closure assumptions

Closure assumptions are required for model experiments because there remain aspects of economic behaviour, or the market mechanism, which are not incorporated within the model. In the case of the general equilibrium model, these relate primarily to the market for productive factors - namely, labour and capital equipment.

5.2.1 Factor market closure

There is a choice here concerning the method in which these markets adjust to the assumed input changes (or 'event') being modelled. Either there is a **'quantity'** adjustment and price is assumed unchanged in the face of the 'event' or, alternatively, there is a **'price'** adjustment and quantity is assumed unchanged.

Specifically, in the labour market the choice is between assuming real wage rates are unchanged or assuming the overall level of employment remains unchanged in response to the event. In other words,

- either, assume the real wage is invariant to the input changes or event.
- or, assume the level of employment is invariant to the input or event.

If the real wage is assumed to remain unchanged then the required adjustment process in the labour market is undertaken through changes in the numbers employed. That is,

given a positive or expansionary 'event;', the labour market adjustment will take place solely through an increase in employment. Clearly, there will be a reduction in employment in the case of a negative or contractionary event being modelled.

If, on the other hand, the level of labour employed is assumed to remain unchanged, then the real wage adjusts in the face of the event being modelled.

For the market for capital equipment, the choice is :

- either, assume the rates of return are invariant to the input changes and so adjustment to the event is undertaken through changes in the quantity of capital equipment utilised by producers.

- or, assume the quantity of capital is invariant to the event and thus adjustment to a shock occurs through changes to rates of return.

Note the consequence of these closure assumptions. On the one hand, assuming unchanged real wages and rates of return will result in additional productive capacity being available in the face of a positive expansionary event. Modelling a negative contractionary event would result in a reduction of the use of productive resources.

On the other hand, assuming unchanged employment and available capital results in a reallocation of existing productive capacity and higher incomes - given a positive event - to employees and the owners of capital equipment.

5.2.2 External sector closure

A further closure assumption relates to the external sector. Here, either the nominal exchange rate or the external current account balance is assumed invariant to the modelled event - ie.

- either, assume the current account balance is unchanged and thus the quantity of foreign borrowing is held fixed in the scenario. Benefits here - in the case of a positive event - are attributed to domestic consumers.

This occurs because the positive expansion leads to an appreciation of the exchange rate, resulting in a higher standard of living and increased consumption for domestic consumers.

For a negative shock the costs are borne by domestic consumers as a result of a depreciation of the exchange rate lowering their standard of living and consumption spending.

- or, assume the nominal exchange rate is unchanged in the scenario and so benefits - in the case of a positive expansion - are attributed to foreigners as overseas debt is repaid. For a negative event, increased overseas debt is accumulated.

5.2.3 Government sector fiscal accounts closure

A further closure assumption relates to the government accounts sector. Here, either income tax rates or the government's fiscal operating balance are assumed invariant to the modelled event - ie.

- either, assume income tax rates are unchanged in the scenario. Benefits here - in the case of a positive event - occur (in the first instance) to the government fiscal position - implicitly resulting in a reduction in outstanding debt.
- or, assume the government's operating balance is unchanged in the scenario, leaving income tax rates to be determined through the modelling process. Benefits here - in the case of a positive expansion - will flow through to income tax payers and, hence, domestic consumers.

5.2.4 Assumptions in model experiment reported below

In the context of the above discussion, note the experiments reported below have been undertaken using the following assumed closures:

- real wage rates unchanged on *Control*
- real rates of return on capital unchanged on *Control*
- nominal exchange rate unchanged on *Control*
- income tax rates unchanged on *Control*

6 RESULTS FROM MODEL EXPERIMENTS

6.1 The release of a crop GMO

Table 6.1 below provides a listing of summary results from scenarios with a release of a crop GMO.

Table 6.1 Results from scenarios with the release of a crop GMO

LABEL	*#1*	*#2*	*#3*	*#3a*	*#3b*	*#3c*	*#6*
% change from CONTROL level							
Real GDP	-2.4	-1.2	-0.1	3.0	-1.3	1.2	2.5
Labour Employment	-2.6	-1.5	-0.5	2.2	-1.9	0.8	2.2
Capital Stock Employed	-2.4	-1.4	-0.5	2.1	-1.7	0.8	2.0
Real Consumption	-1.4	-0.8	-0.3	1.2	-1.0	0.5	1.2
Real Export Volumes	-3.8	-1.9	0.0	5.2	-2.0	2.0	4.1
Import Volumes	-2.3	-1.4	-0.5	1.8	-1.7	0.7	1.9
Trade balance (absolute $m change from *CONTROL* level)	-1108	-683	-271	799	-851	301	881
GDP deflator	0.0	-0.4	-0.7	-1.6	-0.7	-0.7	-0.7
Terms of trade (NZ$)	0.1	-0.4	-0.9	-2.2	-0.8	-1.0	-1.0
*Terms of trade (world$) **	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
EXPORT VOLUMES							
Dairy exports	-7.8	-0.9	6.2	26.5	1.7	10.7	15.2
Meat exports	-8.8	-5.4	-2.0	7.1	-6.7	2.8	7.5
Horticulture	-23.2	-22.0	-20.9	-18.0	-32.8	-8.9	3.0
Tourism exports	-5.7	-5.0	-4.3	-2.5	-7.2	-1.4	1.5
EXPORT RECEIPTS							
Dairy exports	-7.8	-2.7	2.5	16.9	-1.8	6.9	11.2
Meat exports	-8.8	-6.2	-3.7	2.9	-8.4	0.9	5.6
Dairy and meat sub-total	-8.2	-4.1	0.0	11.2	-4.5	4.5	8.9
Horticulture exports	-23.2	-22.3	-21.5	-19.3	-33.3	-9.6	2.3
Tourism exports	-5.7	-5.2	-4.6	-3.3	-7.6	-1.8	1.1

* = imposed, ie **not** model determined

6.1.1 Scenario #1

This experiment simulates the effects of a reduction in demand facing New Zealand exporters of dairy, meat, horticulture and tourism, as a consequence of the release of a crop GMO, but with zero no productivity gains arising from such a GMO. 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.

In this experiment, the lack of any productivity changes coupled with the closure assumption in the labour market which imposes no change in real per-unit labour costs, are reflected in the minimal changes to the price competitiveness of New Zealand-made products. This is indicated through the results for the GDP deflator (0.0% change) and NZ$ terms of trade (0.1% change). Thus with minimal avenues open to reduce production costs, New Zealand dairy, meat, horticulture and tourism exports face the full brunt of the imposed demand contraction. The lower export volumes for each of these commodities, result in overall total export volumes declining 3.8% compared to the *Control* level. Furthermore, with little change in prices, the lower volumes exported translate into lower export receipts as listed in the table.

The lower levels of export volumes furthermore, translate to lower labour employment (remembering the labour market closure assumes no change in real per-unit labour costs ie wage rates). These impacts have further-round general equilibrium effects as domestic consumption is lower than in the *Control* consistent with lower incomes arising from the lower level of employment. Overall GDP turns out to be 2.4% lower.

The reduction in export receipts results in a deterioration in the balance of trade, although this deterioration is mitigated by the reduction in imports arising from the reduced level of overall activity in the New Zealand economy. These two influences result in a $1.1bn deterioration in the balance of trade.

6.1.2 Scenario #2

Imposing the same export demand contraction as in #1 above, but adding the improvement in productivity of 2.5%pa, above *Control*, across half of each of the pastoral industries maintained for five years results in this experiment labelled #2.

The result of the imposed productivity improvements can be seen in the results for the GDP deflator and the NZ$ terms of trade. These results reflect the lower costs of production in New Zealand and, consequently, the improved price competitiveness of New Zealand-made products.

The effect of this improved competitiveness mitigates the impacts from the demand contractions. However, the results of this model experiment show that the competitiveness improvement is of insufficient magnitude in this case to outweigh the effects of the demand contraction. As a result, overall GDP, exports and employment are recorded as being lower than in the *Control* - although not by as much as in the above #1 experiment. For example, GDP is 1.2% below *Control* compared to 2.4% below in experiment #1.

Further investigation illustrates the relative improvement of the dairy and meat export commodities (compared to #1) as the direct beneficiaries of the imposed productivity gains, while the results for horticulture and tourism exports remain close to their #1 levels.

In summary, the results of #2 suggest that while imposed productivity improvements definitely mitigate the negative impact from the assumed export demand contraction, the size of the productivity gain required to totally outweigh such negative impacts is clearly larger than that imposed in this experiment.

6.1.3 Scenario #3

This experiment investigates the effects of a larger productivity improvement. In particular, this effectively doubles the cost reductions imposed in experiment #2 by assuming a 2.5%pa productivity gain over 50% of all pastoral agriculture maintained for 10 years. Note that the demand curve contraction imposed here is that same as that imposed in both experiments #1 and #2 - ie equivalent to that calculated using the survey responses.

The results for experiment #3, at the overall GDP level, show that in this case the effects from the productivity gain is sufficient to almost outweigh the effects of the negative demand contraction. In particular, the cost reductions summarised in the -0.7% result for the GDP deflator are sufficient to result in total export volumes being close to those in the *Control* - with the table of results showing a 0.0% change.

Overall, this 'balance' between these two influences is reflected in an overall GDP of 0.1% lower than the *Control* level.

The industry and commodity composition of the demand and productivity impacts however, leave a negative 0.5% impact on total employment - which consequently flows through to slightly lower consumption (down 0.3%) and imports (down 0.5%) compared to the *Control* levels.

At the commodity level of detail, it is noticeable that the impact of the productivity gains are particularly concentrated in the dairy sector. These result in the model experiment showing an overall positive effect (up 6.2%) on dairy export volumes despite the negative demand contraction being faced in this instance. Constraints on New Zealand's abilities to expand (above *Control*) dairy export volumes (in the form of quotas, regulations and other effective barriers) by this amount need to be noted. If these constraints make the 6.2% above *Control* figure difficult to realise then the 'weight' of the positive influences reflected in the results of this experiment would be consequentially reduced.

6.1.4 Scenario #3a

This experiment imposes greater productivity improvements - of the order of 4%pa above *Control*, over 75% of all pastoral agriculture maintained for 10 years - but retaining the same demand contractions assumed for the earlier experiments #1 to #3.

The results here provide an indication of potential significant gains - ranging from overall GDP 3.0% and employment 2.2% higher than *Control* to total export volumes 5.2% above those in the *Control* - despite the demand contractions.

A cautionary note in regard to this simulation needs to be stated. This surrounds the achievability of such export volume expansions - especially as in this experiment they incorporate significant increases in dairy and meat exports. The earlier comment with regard to New Zealand exporters of these commodities facing quotas and suchlike applies here with even more force.

Of equal significance in this model experiment is information contained in the commodity detail of the results. In particular, despite the productivity improvements in pastoral agriculture, there remains below-*Control* export volumes recorded for the horticulture and tourism categories. In other words, while the productivity gains may more than outweigh the demand contractions at the overall GDP level and for particular pastoral export commodities, the impact of the imposed demand contractions faced by horticulture and tourism exporters remains significant.

6.1.5 Scenario #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.

Clearly, 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.

6.1.6 Scenario #3c

In this experiment the export demand contraction in this experiment 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 shows through in an improvement in the balance of trade to the tune of $300m, compared to that in the *Control*. It should be noted that export receipts do not rise as much as export volumes - a clear 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 are a direct result of the imposed productivity gains. Put alternatively, if productivity gains are not achieved such price reductions can not be offered and the consequential volume growth - in the face of the demand contraction is not attainable. Such is the nature of the general equilibrium solution.

Again - with respect to the results for experiment #3c - it is important to restate concerns surrounding the nature of the gains as, in this case, they incorporate significant increases (above those in the *Control* simulation) in dairy exports. In this case, notes concerning the impact of quotas, regulations and suchlike are of more force than those noted for #3, but are not as great as those noted for #3a.

Tourism export volumes are 1.4% below *Control*, with revenues down 1.8%. The outcome for this category of exports in this experiment are the least reduction - when compared to the other crop GMO experiments described above.

6.1.7 Scenario #6

The impact of the productivity gains alone are reflected in the results listed for experiment #6. The imposed productivity gains are equivalent to those assumed in #3, but in #6 there is no demand contraction imposed.

With only the positive influences from the assumed productivity gains present in this experiment, an overall gain to GDP, employment, consumption and total exports is not surprising. In particular, the productivity gain above *Control* imposed of 2.5%pa over 50% of pastoral agriculture maintained for 10 years, results in GDP 2.5% higher than *Control*, with employment up 2.2% and total export volumes 4.1% higher.

Again, it is noticeable that the benefits from the imposed productivity gains are concentrated in the dairy and meat export commodities. This is a clear reflection of the crop-GMO-induced productivity assumed in these scenarios. The concentration of the gains in these particular commodities makes further reinforces the requirement that export volume expansions by these commodities are not constrained by other market barriers.

6.2 The release of a bio-control GMO

Table 6.2 below provides a listing of summary results from scenarios with a release of a bio-control GMO.

Table 6.2 Results from scenarios with the release of a bio-control GMO

LABEL	*#4*	*#4a*	*#4b*	*#4c*	*#5*
% change from CONTROL level					
Real GDP	-1.3	-2.5	1.2	-0.1	-0.3
Labour Employment	-1.6	-2.9	1.0	-0.3	-0.7
Capital Stock Employed	-1.5	-2.7	1.0	-0.3	-0.6
Real Consumption	-0.8	-1.6	0.6	-0.1	-0.4
Real Export Volumes	-2.0	-4.0	1.9	0.0	-0.3
Import Volumes	-1.4	-2.6	0.9	-0.3	-0.7
Trade balance (absolute $m change from *CONTROL* level)	-708	-1276	421	-147	-341
GDP deflator	-0.3	-0.3	-0.3	-0.3	-0.6
Terms of trade (NZ$)	-0.4	-0.3	-0.5	-0.4	-0.8
*Terms of trade (world$) **	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
EXPORT VOLUMES					
Dairy exports	-1.3	-5.5	7.1	2.9	5.0
Meat exports	-5.6	-10.1	3.6	-1.0	-2.5
Horticulture	-22.1	-33.9	1.5	-10.3	-21.1
Tourism exports	-5.0	-8.0	0.7	-2.2	-4.4
EXPORT RECEIPTS					
Dairy exports	-3.0	-7.1	5.2	1.1	1.6
Meat exports	-6.4	-10.9	2.7	-1.9	-4.1
Dairy and meat sub-total	-4.4	-8.6	4.2	-0.1	-0.7
Horticulture exports	-22.4	-34.1	1.1	-10.6	-21.6
Tourism exports	-5.2	-8.1	0.6	-2.4	-4.7

* = imposed, ie **not** model determined

6.2.1 Scenario #4

In this experiment the imposed productivity improvements arising from the release of a bio-control GMO are assumed as a moderately successful reduction in the incidence of bovine Tb resulting from the control of possums. In particular, a reduction by half in the incidence of bovine Tb improves productivity (by reducing the number of cattle required to be killed) dairy and sheep and beef farming by 6% above *Control*. Experiment #4 assumes this productivity gain as well as imposing the same export demand contraction as that assumed in #1.

The result of this experiment indicates the 'balance' of these two forces is weighted towards the negative impacts from the demand contraction. Put alternatively, the imposed productivity gains are not large enough to outweigh the negative demand reaction against all New Zealand produce and tourism, as surveyed, from the release of GMOs in New Zealand.

Similar to the crop GMO scenarios described earlier, the nature of the productivity gains are concentrated in the dairy export commodities. As such, horticulture exports in particular face the brunt of the demand reaction but gain little price-competitiveness advantages given their lack of benefit from the imposed productivity gain.

Consequently, GDP is 1.3% lower than *Control*, with employment 1.6% lower and total exports 2% down.

6.2.2 Scenario #4a

This experiment imposes the same productivity assumptions as in the previous 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 - reflected in the overall GDP deflator being 0.3% lower than *Control* - are clearly insufficient to outweigh the magnitude of the demand reaction imposed in this experiment.

6.2.3 Scenario #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 - as reflected in the GDP deflator being 0.3% below *Control* - 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 are also felt as their export volumes and receipts record above-*Control* outcomes.

6.2.4 Scenario #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.

The consequence of this assumption is to result 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 bio-control-GMO-induced productivity gains. Labour employment is reduced by a slightly larger margin than that for overall employment - a consequence of the industry and commodity composition of the demand and productivity effects.

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 little benefit it directly receives from the imposed productivity gains.

6.2.5 Scenario #5

This experiment reverts to the survey-based export demand contraction (as in #4), but imposes a greater (above *Control*) productivity improvement on agriculture. The 12% productivity gain imposed here arises from the assumption of a fully successful elimination of bovine Tb resulting from the control of possums through the release of a GMO.

In comparison to #4, it is noticeable that the additional productivity gain imposed in #5 is still insufficient to outweigh the negative effects of the demand contraction. In

particular, GDP is 0.3% below *Control*, employment 0.7% down, consumption 0.4% down and total exports 0.3% below the level of that in the *Control*.

It is also noticeable that while dairy and meat exports perform noticeably better when compared to the outcome in #4, the effects on horticulture and tourism exports remain considerably negative - a reflection of the concentration of the productivity gain within the dairy and sheep & beef farming sectors.

6.3 NZ refrains from using GMOs

Table 6.3 below provides a listing of summary results from scenarios where New Zealand refrains from using GMOs.

Table 6.3 Results from scenarios where NZ refrains from use of GMOs

LABEL	*#7*	*#8*	*#9*	*#9a*	*#10*	*#10a*	*#10b*	*#E1*	*#E2*
% change from CONTROL level									
Real GDP	7.5	3.4	-0.1	-5.7	-6.4	-3.2	3.2	11.3	-11.2
Labour Employment	8.0	3.9	0.2	-5.6	-6.5	-3.1	3.7	12.1	-11.5
Capital Stock Employed	7.5	3.4	-0.1	-5.7	-6.4	-3.2	3.2	11.3	-11.2
Real Consumption	4.3	2.0	0.0	-3.2	-3.6	-1.8	1.9	6.5	-6.3
Real Export Volumes	12.2	5.9	0.4	-8.3	-9.9	-4.7	5.7	18.3	-17.4
Import Volumes	7.4	3.8	0.6	-4.5	-5.7	-2.5	3.8	11.2	-10.1
Trade balance (absolute $m change from *CONTROL* level)	3543	1709	113	-2441	-2890	-1373	1653	5292	-5075
GDP deflator	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1
Terms of trade (NZ$)	-0.2	0.1	0.3	0.7	0.4	0.4	0.2	-0.2	0.8
*Terms of trade (world$) **	*0.0*	*-1.4*	*-2.9*	*-6.6*	*-2.9*	*-2.9*	*-2.9*	*0.0*	*-6.6*
EXPORT VOLUMES									
Dairy exports	13.8	-12.7	-35.5	-72.7	-43.3	-39.3	-31.5	20.7	-76.0
Meat exports	15.5	-11.4	-34.5	-72.3	-43.3	-38.9	-30.1	23.2	-76.0
Horticulture	34.4	3.1	-23.9	-67.8	-43.3	-33.5	-14.0	51.7	-76.0
Tourism exports	34.4	34.3	34.0	34.2	-0.1	17.2	51.5	51.7	-0.1
EXPORT RECEIPTS									
Dairy exports	13.8	-12.7	-35.5	-72.7	-43.3	-39.3	-31.5	20.7	-76.0
Meat exports	15.5	-11.4	-34.5	-72.3	-43.3	-38.9	-30.1	23.2	-76.0
Dairy and meat sub-total	14.5	-12.2	-35.1	-72.5	-43.3	-39.1	-30.9	21.7	-76.0
Horticulture exports	34.4	3.1	-23.9	-67.8	-43.3	-33.5	-14.0	51.6	-76.0
Tourism exports	34.4	34.3	34.0	34.2	0.0	17.2	51.5	51.6	-0.1

* = imposed, ie **not** model determined

6.3.1 Scenario #7

This experiment imposes demand expansions, as consistent with the survey responses, applicable to New Zealand exports of dairy, meat, horticulture and tourism exports. Furthermore, experiment #7 assumes there are no relative productivity gains enjoyed by the rest of the world (in particular, by those competing against New Zealand products) through their use of GMOs and New Zealand refraining from such use.

With only the positive influences from the export demand expansions present in this experiment, an overall gain to GDP, employment, consumption and total exports is not surprising. In particular, the demand expansions above *Control* imposed of 13.7% for dairy, 15.4% for meat and 34.3% for each of horticulture and tourism, results in GDP 7.5% higher than *Control*, with employment up 8.0% and total export volumes 12.2% higher.

That the gains are a direct result of these demand expansions is reinforced by the commodity detail of the export gains, with the concentration in the actual export outcome being clearly in the dairy, meat, horticulture and tourism categories. Indeed, there is little change in New Zealand exporters' price competitiveness situation - indicated by the GDP deflator changing by only 0.1% and NZ$ terms of trade down 0.2% compared to *Control*.

As noted in some of the previous GMO scenarios, expansions concentrated on significant increases above *Control* in dairy and meat exports should be interpreted with some caution due to the market access and regulation difficulties faced by New Zealand exporters of such commodities. This comment is clearly applicable to the results of this model experiment.

It should also be noted that the employment gain in this simulation (8.0% above *Control*) should also be interpreted with caution. In particular the assumed labour market closure where real per-unit labour costs (ie real wage rates) are unchanged compared to *Control* is likely to be inappropriate in the face of an increase in labour demand of this magnitude. In such a case, where this closure assumption is modified to allow for some rise in real wages - the gains to real GDP, exports, consumption and consequently employment will be correspondingly less than that recorded in #7. In other words, some of the benefits from a scenario akin to #7 are likely to be 'enjoyed' in the form of real wage rate increases and not solely employment gains as has been modelled here.

6.3.2 Scenario #8

Experiment #8 retains the same demand curve expansions as imposed in #7, but simulates the effects of a productivity gain of 6.4% enjoyed by producers competing against New Zealand dairy, meat and horticulture exports.

The results of this experiment show the impact of the consequential deterioration in New Zealand exporters' price competitiveness position lead to a more than halving of the overall gains recorded in experiment #7. Nevertheless, the overall gains to the New Zealand economy compared to the *Control* remain significant. In particular, GDP is 3.4% higher, with employment up 3.9%, consumption 2.0% higher and total export volumes up 5.9%.

A noticeable feature of this scenario however, is the negative outcome for dairy and meat exports, despite the favourable demand curve shift imposed in this experiment. Put alternatively, the impact of the loss of price competitiveness in these particular commodities substantially outweighs the impact of the favourable demand shift. In this experiment therefore, the overall positive outcome hinges on the performance of tourism exports in being able to take full advantage of the imposed favourable demand curve shift given New Zealand refraining from using GMOs - as per the survey responses.

6.3.3 Scenario #9

This experiment assumes the same export demand expansion as imposed for #7 and #8, but doubles the assumed productivity gains enjoyed by New Zealand's competitors to 13.2%.

In this case the overall positive impact on GDP from the favourable demand shift is almost wholly negated by the effects of the loss in price competitiveness. In particular, although tourism exports continue to take full advantage of the export demand expansion, the negative consequences for dairy, meat and horticulture exports are more than considerable.

As a result overall GDP is almost unchanged from the *Control* level (down 0.1%), as is employment (up 0.2%) and consumption (0.0%) and total export volumes (up 0.4%).

6.3.4 Scenario #9a

Pursuing the sensitivity of the results to the magnitude of the imposed productivity gains enjoyed by New Zealand's competitors, experiment #9a imposes the same demand expansion as in #9, but more than doubles the relative productivity gains in the rest of the world to 30% (compared to *Control*).

Clearly the results of this experiment are listed as significantly negative compared to *Control*.

This result should be interpreted with caution as the magnitude of the employment reduction, in particular, calls into question the appropriateness of the labour market closure assumption. That is, it is unlikely that real wage rates would remain unchanged (compared to *Control*) in the face of employment being 5.6% below *Control*. If this

closure assumption was modified to allow an adjustment in real wage rates - and, hence, the per-unit cost of labour - the real impacts suggested by this experiment would be mitigated to some extent.

6.3.5 Scenario #10

This experiment imposes relative productivity gains enjoyed by New Zealand's competitors of the order of 13.2% - as per experiment #9 - but with no demand expansion. With only the negative influences from the imposed productivity gains by the rest of the world present in this experiment, an overall negative impact on GDP, employment, consumption, and total exports is expected.

It is clear that the loss of price competitiveness faced by New Zealand dairy, meat and horticulture exporters are not balanced by any mitigating influences in this experiment. In particular, there is no favourable demand shift for New Zealand tourism exporters - as was present in the earlier experiments #7, #8 and #9.

Again, the magnitude of the negative outcome here should be interpreted with caution. For reasons similar to that noted for experiment #9a, the size of the employment reduction recorded here in #10 calls into question the appropriateness of the labour market closure assumption. It is more than unlikely that real wage rates would remain unchanged (compared to *Control*) in the face of employment being 6.5% below *Control*. Modifying the closure assumption to allow some reduction in real wage rates (compared to *Control*) - and, hence, lower per-unit labour costs - would mitigate to some degree the real impacts suggested by the experiment results here.

6.3.6 Scenario #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 demand shift of half that implied by the survey responses (ie half those imposed in #9).

The results here sees 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.

Again, 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 deteriorates by nearly $1.4bn (compared to *Control*).

6.3.7 Scenario #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 the 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.

6.3.8 Scenario #E1 and #E2

These two experiments, for the record, depict two cases at either end of the spectrum of input assumptions imposed in those experiments where New Zealand refrains from using GMOs.

In the case of experiment #E1, the rest of world is assumed to enjoy no relative productivity gains while New Zealand exporters benefit from a demand shift of the order of 50% above those implied by the survey responses. With only the positive influences from the export demand expansions present in this experiment, the overall gain to GDP, employment, consumption and total exports is as expected.

In the case of experiment #E2, the rest of world is assumed to enjoy relative productivity gains over their New Zealand counterparts to the tune of 30% while New Zealand exporters experience no favourable demand shift. With only the negative influences from the imposed productivity gains by the rest of the world present in this experiment, the overall negative impact on GDP, employment, consumption, and total exports is as expected.

Again, in both of these experiments the magnitude of outcomes here should be interpreted with caution. In particular, the appropriateness of the labour market closure assumption is more than questionable in these two experiments. It is more than unlikely that real wage rates would remain unchanged (compared to *Control*) in the face of employment changes recorded in either of #E1 or #E2. Modifying the closure assumptions here to allow some real wage rate adjustments (compared to *Control*) modify the magnitude (although not the direction) of the real impacts listed by the experiment results here.

6.4 The release of a human medicine GMO

Table 6.4 below provides a listing of summary results from scenarios with a release of a human medicine GMO.

Table 6.4 Results from scenarios with the release of a human medicine GMO

LABEL	*#11*	*#12*	*#13*	*#14*	*#14a*	*#14b*
% change from CONTROL level						
Real GDP	-0.9	0.4	1.4	-1.4	-0.2	-0.5
Labour Employment	-0.9	0.1	0.8	-1.3	-0.2	-0.5
Capital Stock Employed	-1.2	0.3	1.5	-1.8	-0.2	-0.6
Real Consumption	-1.3	0.2	1.5	-2.0	-0.3	-0.7
Real Export Volumes	-0.9	0.2	1.1	-1.4	-0.2	-0.5
Import Volumes	-1.4	-0.4	0.4	-2.0	-0.3	-0.7
Trade balance (absolute $m change from *CONTROL* level)	158	268	344	238	42	74
GDP deflator	-0.3	-0.7	-0.9	-0.5	-0.1	-0.2
Terms of trade (NZ$)	-0.3	-0.5	-0.7	-0.5	-0.1	-0.1
*Terms of trade (world$) **	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*
EXPORT VOLUMES						
Dairy exports	-2.8	-1.9	-1.3	-4.3	-0.7	-1.5
Meat exports	-3.3	-2.4	-1.8	-5.0	-0.7	-1.7
Horticulture	-10.9	-10.2	-9.6	-16.0	-0.7	-5.3
Tourism exports	-1.7	-0.8	-0.1	-2.6	-0.7	-0.9
EXPORT RECEIPTS						
Dairy exports	-3.1	-2.4	-1.9	-4.7	-0.8	-1.6
Meat exports	-3.6	-2.9	-2.4	-5.4	-0.8	-1.8
Dairy and meat sub-total	-3.2	-2.6	-2.1	-4.9	-0.8	-1.7
Horticulture exports	-11.2	-10.7	-10.3	-16.4	-0.8	-5.5
Tourism exports	-2.0	-1.3	-0.8	-3.1	-0.8	-1.1

* = imposed, ie **not** model determined

6.4.1 Scenario #11

The framework and the input assumptions for this experiment #11 are conceptually analogous to that of the first scenario experiment #1. That is, it provides a picture of the economy on the assumption that the development of a GMO-based human therapeutic 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 (compared to that in experiment #1), simply

because the reduction in export is demand is assumed to be less severe than with a GMO-based development related to food production.

6.4.2 Scenario #12

Scenario #12 incorporates into #11 the effect of $200m worth of exports of GMO-derived proteins, plus on-going research and development expenditure of $5m per annum.

These changes provide positive gains that outweigh 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 $200m 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.

6.4.3 Scenario #13

The $200m of protein exports could well be a conservative estimate. In experiment #13 it is assumed that $400m 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 the levels in the *Control*, but over the 10 year horizon the difference in their rates of growth is less than 1% per annum.

6.4.4 Scenario #14

Experiment ref#14 reverts to the framework in experiment #11, but 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 bio-control GMO scenarios.

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

6.4.5 Scenario #14a and #14b

These two experiments provide further indications of the sensitivity of the results of the scenarios where New Zealand releases a human medicine GMO to the imposed export demand contractions.

In experiment #14a, a minimal demand contraction of only 1% (compared to *Control*) is imposed on dairy, meat, horticulture and tourism exports. The outcome here is of a marginal deterioration in overall economic activity (compared to *Control*), noticeably concentrated on the four previously mentioned export commodities.

In experiment #14b, the demand contraction imposed 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 the outcome from experiment #11 and that for #14a.

6.5 A combined scenario

Table 6.5 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 $200m 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) are evenly-poised, the addition of $200m 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.

Table 6.5 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 $m change from *CONTROL* level)	-178
GDP deflator	-1.0
Terms of trade (NZ$)	-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 sub-total	0.6
Horticulture exports	-21.1
Tourism exports	-4.0

* = imposed, ie **not** model determined

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.

Report to
MINISTRY FOR THE ENVIRONMENT

APPENDIX 7
TO

ECONOMIC RISKS AND OPPORTUNITIES FROM THE RELEASE OF GENETICALLY MODIFIED ORGANISMS IN NEW ZEALAND

LTEM Model details

The LTEM model

In this section of the research, a partial equilibrium (PE) model, the LTEM (Lincoln Trade and Environment Model), is used to quantify the price, supply, demand and net trade effects of various policy and non-policy induced shocks. The LTEM is an agricultural multi-country, multi-commodity trade model. It is based upon VORSIM[i] which has evolved from SWOPSIM and associated trade-database used to conduct analyses during the Uruguay Round (Roningen, 1986; Roningen et al., 1991). The LTEM is modified in this study to quantify the global and regional effects of farmers' adopting GM technology in production, consumers' preference changes in relation to GM products and policy induced shocks on imports of GM products.

Although a PE framework uses a "standard approach" to model international trade policy, analysts tend to prefer PE frameworks in quantifying the effects of domestic agricultural and trade policy measures based on factors such as the level of commodity disaggregation, ease of traceability of the interactions, transparency of the results, relatively small size of the models, the number of behavioral parameters and the methods used to obtain those parameters (Francois and Hall, 1997; Roningen, 1997; Gaisford and Kerr, 2000; Beers and Bergh, 1996)[ii].

There are 9 countries and 14 agricultural commodities included in the model (see Appendix Table A1 for the list of these countries and commodities). The commodities included in the model are treated as homogenous with respect to country of origin and destination. Therefore commodities are perfect substitutes in consumption in international markets, and importers and exporters are assumed to be indifferent about their trade partners. Based on these the model is built as a non-spatial type which emphasizes the net trade of commodities in each region. However, the supply and demand shares of countries in trade can be traced down.

The LTEM is a synthetic model as the parameters are adopted from the literature. The interdependencies between primary and processed products and/or between substitutes are reflected by cross-price elasticities. The policy parameters and/or variables are listed in Appendix Table A2. The economic welfare implications of policy changes can also be calculated in the LTEM using the producer and consumer surplus measures. The model is used to derive the medium- to long-term (till 2010) policy impact in a comparative static fashion, basing the beginning date to 1997. The model provides short-run solutions as well, since it applies a sequential simulation procedure year by year in which the stock change is used to link two consecutive years.

In general there are six behavioural equations and one economic identity for each commodity under each country in the LTEM framework. Therefore, there are seven endogenous variables in the structural-form of the equation set for a commodity under each country[iii]. There are four exogenously determined variables[iv], but the number of exogenous variables in the structural-form equation set for a commodity vary based on the cross-price, cross-commodity relationships. The behavioral equations are domestic

supply, demand, stocks, domestic producer and consumer price functions and the trade price equation. The economic identity is the net trade equation which is equal to excess supply or demand in the domestic economy. For some products the number of behavioral equations may change as the total demand is disaggregated into food, feed, processing industry demand, and are determined endogenously. The behavioral equations and parameters related to these commodities and quantification of domestic agricultural and trade policies are described in more detail in Cagatay and Saunders 2003.

Basically, the model works by simulating the commodity based world market clearing price on the domestic quantities and prices, which may or may not be under the effect of policy changes, in each country. Excess domestic supply or demand in each country spills over onto the world market to determine world prices. The world market-clearing price is determined at the level that equilibrates the total excess demand and supply of each commodity in the world market using a non-linear optimization algorithm (Newton's global or search algorithm[v]).

Behavioral Specifics and Incorporation of Policy Shocks to the Main LTEM Structure

The sectoral focus of this study is dairy, meat, fruits and grains. Here the LTEM is explained using the dairy and fruit sectors as examples. This is followed by an explanation of the grains sector using maize as the example.

In dairy sector models a major challenge is to exhaust the domestic supply of raw milk that can be consumed in various forms (Lariviere and Meilke, 1999). In the applied literature there are two main approaches used to model dairy sector supply and demand. The first and more traditional approach deals with dairy products in terms of raw milk equivalents. Various components of raw milk produce a variety of dairy products when combined in different proportions. This constant raw milk equivalents approach, although inaccurate in some cases, can be useful, since dairy products are assumed to be homogenous in most of the international dairy models. However, lack of data on some fresh dairy products sometimes may result in aggregation of these categories into one single category, fluid milk, which is treated as a nontradable good (Lariviere and Meilke, 1999). The second approach allocates raw milk to various product categories such as fluid milk, cheese etc. in a hierarchical fashion and the rest and left over is then assumed to be processed for butter and skim milk powder production. Although this allocation mechanism is consistent with the dairy policies in most of the major markets, market conditions such as changing relative prices and product based domestic and border polices do not play any role in the allocation mechanism except by assumption. This approach also lacks information about marginal production costs since a supply curve is not estimated (Lariviere and Meilke, 1999). As the dairy markets are under the effect of various domestic and border policies a third approach, explicit modelling of dairy sector supply and demand –which is the approach taken here-, becomes essential in modelling the various policy impacts as well as the full exhaustion of the domestic supply of raw milk into various demand categories.

Domestic Supply. In the LTEM framework, a uniform Cobb-Douglas (CD) constant elasticity functional form is specified at the level of the variables to reflect the aggregate domestic supply response of each commodity in each country with respect to the own-

and cross-prices. Colman (1983) refers to this type of agricultural supply response function, whose theoretical underpinnings are of an *ad hoc* nature (assumed to be derived from producers' profit maximization problem), as directly estimated partial supply response models. An agricultural commodity is assumed to be produced in a single farm and therefore the agricultural sector is treated as a single multi-product farm producing under perfect competition and producers are assumed price takers in the domestic market. The conditions that allow this exact aggregation are given in Moschini (1989).

The dairy sector is modeled as five commodities. Raw milk is defined as the farm gate product and is then allocated to the liquid milk, butter, cheese, whole milk powder or skim milk powder markets depending upon their relative prices subject to physical constraints. The domestic supply (*qs*) function for raw milk (qs_{mi}) is shown in equation A1. In equation A1, the subscript $_m$ stands for the country, $_i$ represents raw milk and $_j$ represents substitute commodities such as beef and veal, and $_k$ represents feed products such as wheat, coarse grain and oil meals. The variables *pp* and *pc* represent the producer and consumer price level respectively. Therefore, domestic supply of raw milk is specified as a function of producer price for raw milk, beef, and consumer prices of feed inputs. Domestic supply is assumed to adjust simultaneously to price changes. The own-price elasticity of supply is illustrated by the exponent $?_{ii}$ and is positive. The cross-price supply elasticity with respect to beef price ($?_{ij}$) and feed products ($?_{ik}$) are negative, as raw milk and beef are assumed to be gross substitutes, and feed products are the production inputs.

The domestic supply of dairy products (liquid milk, butter, cheese, skim and whole milk powder) is determined based on the raw milk production (qs_{mi}) which reflects the physical constraint on processed dairy production, and producer prices of various dairy products. For example, in equation A2, domestic supply of liquid milk (qs_{ml}) is specified as a function of qs_{mi}, producer price of liquid milk (pp_{ml}) and producer prices of other dairy products (pp_{mh}). The exponentials $?_{li}$, $?_{ll}$ and $?_{lh}$ show the supply elasticity of liquid milk with respect to raw milk production, producer price of liquid milk and producer prices of other dairy products respectively. The supply side parameters used in the LTEM are presented in Appendix Table A3.

$$qs_{mi} = a_{i0}\, pp_{mi}^{\,a_{ii}}\, pp_{mj}^{\,a_{ij}} \prod_k pc_{mk}^{\,a_{ik}}\ ; \qquad a_{ii} > 0,\ a_{ij} < 0,\ a_{ik} < 0 \qquad \text{A1}$$

$$qs_{ml} = b_{l0}\, qs_{mi}^{\,b_{li}}\, pp_{ml}^{\,b_{ll}} \prod_h pp_{mh}^{\,b_{lh}}\ ; \qquad b_{li} > 0,\ b_{ll} > 0,\ b_{lh} < 0 \qquad \text{A2}$$

$_h$: butter, cheese, skim and whole milk powder
$_i$: raw milk
$_j$: beef and veal
$_k$: feed crops
$_l$: liquid milk

A common approach used to model supply response in the fruit sector is to model acreage and yield separately (Marzouk, 1972; Roosen, 1999). While price expectations are used to model acreage, current year's price and climate conditions are used generally to determine the yield. The approach used to model domestic supply in the fruit sector in the LTEM focuses on the allocation of apples and kiwifruit between fresh and processing use, so focuses on the fresh yield. A CD function is used to model the supply in these sectors and is specified as a function of current year's price and a trend which proxies the technological advances such as better cultivation technique, better care etc, equation A3. Because the emphasis is not on the acreage decision of farmers no lags in prices (expectations) are included as explanatory variables (Voorthuizen et al., 2002).

$$qs_{ma,k} = g_{a,k0}\, pp_{ma,k}^{\,g_{a,k}}\, tr_t; \qquad a_{a,k} > 0 \qquad \text{A3}$$

$_{a,k}$: apples and kiwifruit

In order to analyse the effects of the production quota in the dairy sector, the supply function is respecified to include an exogenously determined policy variable that constraints the total domestic production at the maximum quota level, equation A4. The production quota, pq_{mi}, becomes a decision variable for the solution algorithm, which becomes binding if the calculated equilibrium quantity in the mathematical solution procedure is greater than or equal to this quota amount. A mathematical MIN function integrated to the supply equation is used for this purpose. With this method the production quota amount becomes binding if the calculated equilibrium qs_{mi} is greater than the pq_{mi}, and the model is pushed to choose pq_{mi} as the solution value. If the calculated equilibrium qs_{mi} is less than the pq_{mi}, then the model continues with the calculated qs_{mi} as the solution amount.

$$qs_{mi} = MIN\left((a_{i0}\, shf_{qs}^{\,1}\, pp_{mi}^{\,a_{ii}}\, pp_{mj}^{\,a_{ij}} \prod_k pc_{mk}^{\,a_{ik}}),\, pq_{mi}\right) \qquad \text{A4}$$

The variable shf_{qs}, in equation A4, proxies the supply side shift factors, and is commonly used in PE trade models such as GAP (Salomon, 1998a; 1998b), GLS (Tyers and Anderson, 1986), SPEL (Henrichsmeyer, 1990), WATSIM (Lampe, 1998). This is used in most modelling exercises to simulate the effects of land set-aside policy (although not active in this study) by shifting the supply curve downward/upward by changing it exogenously at the determined policy level from 1.

Domestic Demand. A uniform CD type aggregate domestic demand function is used in the LTEM framework for each commodity and country. The behavioural relationship is assumed to be derived from the consumer's utility maximization problem (at an *ad hoc* nature) acting under perfect competition. Domestic demand is assumed to adjust simultaneously to price changes. The variables per capita income and population are exogenous to the model, and the interdependencies between primary and processed products and/or between substitutes are reflected by cross-price elasticities.

As the produced raw milk is consumed and exhausted in various forms of dairy products, the domestic demand for raw milk is not modelled in the LTEM, instead the demands for dairy products are modeled endogenously at the country level. The aggregate domestic demand relationship for dairy products is given by equation A5[vi]. In this equation domestic demand for liquid milk, qd_{ml} is defined as a function of consumer prices of the own (pc_{ml}), substitute and complementary commodities (pc_{mh}), per capita income $(pinc_m)$ and population growth rate (pop_m). The exponents reflect the related elasticities. The cross-price demand elasticity ($?_{lh}$) with respect to prices of other raw milk products is positive, since these products are assumed to be gross substitutes with liquid milk. The elasticity of demand with respect to income ($?_{l2}$) and population growth ($?_{l3}$) is also expected to be positive. In order to analyse the effects of demand side shifters other than income and population growth, the demand function is respecified to include an exogenously determined shift factor (shf_{qm}) which is given the value 1 initially, equation 6.

$$qd_{ml} = d_{l0} shf_{qm}^{\ 1} pc_{ml}^{\ d_{ll}} pinc_m^{\ d_{l2}} pop_m^{\ d_{l3}} \prod_h pc_{mh}^{\ d_{lh}}; \quad d_{l1} < 0,\ d_{l2} > 0,\ d_{l3} > 0,\ d_{lh} > 0$$

A5

The demand for apple and kiwifruit is modeled at final consumption level, which covers fresh fruit production only. The demand is specified as a function of own-price, per capita income and population growth.

Stocks. The stocks are explicitly modelled in the LTEM framework based upon the inventory demand theory (FAPRI, 1989). The determinants of the stock demand are the transaction and speculative motives, which respond to the quantity of production or consumption, and to the consumer prices. In the dairy market it is assumed that raw milk is stocked in the form of butter, cheese and skim milk powder. The behavioral equation for stock demand is given as in equation A6. In this equation $?_{h1}$ represents the elasticity of stock demand with respect to the quantity of supply, and is assumed to be positive. The coefficient $?_{h2}$ represents the consumer price elasticity of the stock and is expected to be negative. In the LTEM stocks are not modeled in apple and kiwifruit markets.

$$qe_{mh} = j_{h0} qs_{mh}^{\ j_{h1}} pc_{mh}^{\ j_{h2}}; \qquad j_{h1} > 0,\ j_{h2} < 0$$

A6

Net Trade. The net trade function for a commodity and country is defined as an economic identity which accounts for the difference between domestic supply and the sum of various demand amounts and stocks. Stocks are incorporated as change from the previous year, $?qe_m$, therefore it is the difference between ending stocks at time $_{t-1}$ (which is the beginning stocks at time $_t$) and estimated stocks at time $_t$. (which is the ending stocks at time $_t$). Since it is assumed that all produced raw milk is utilized in the form of processed products, raw milk is not traded. The net trade identity for the liquid milk and fruit sector is given in equation A7, and other dairy products are presented in equation A8.

$$qt_{ml} = qs_{ml} - qd_{ml}$$

A7

$$qt_{mh} = qs_{mh} - qd_{mh} - \Delta qe_{mh}$$

A8

Prices. The domestic producer (pp_m) and consumer prices (pc_m) in the LTEM are determined by the trade price (pt_m) of the related commodity and country border policies that affect domestic prices (tp_m and tc_m) and transportation costs (tc), which are assumed to be zero. Equations A10 and A11 present this price transmission mechanism, which consists of protection, $tp_{mh,l}$ and $tc_{mh,l}$, and stabilization ($WDp_{h,l}/ex_m)^{??}$ components (Tyers and Anderson, 1986), for all the products in the LTEM framework. The trade price of a commodity in a country is determined by the world market price of that commodity, equation A9. The variable ex_m is the nominal exchange rate and the parameter $?_?$ shows the price transmission elasticity. The price transmission elasticity shows how much a change in world prices is transmitted to the domestic market, of which the effect is referred to as the stabilization component. If a country for example is applying a fixed-price policy for a certain commodity then $?_?$ takes the value of 0, or instead if there is a completely free market policy then $?_?$ equals 1. Border policies such as per unit import tariffs (or taxes) and export subsidies and taxes are incorporated in the price transmission mechanism through the use of commodity based price wedge variables, $tp_{mh,l}$ and $tc_{mh,l}$, which differentiate the domestic and trade price of the commodity. When there are no border policy measures that affect domestic prices (protection component is 0) and under the assumptions of no transportation costs and homogenous, perfectly substitutable products, then the domestic producer and consumer prices are determined by the stabilization component and defined as in equations A10 and A11.

$$pt_{mh,l} = \left(\frac{WDp_{h,l}}{ex_m} \right)^{e_t}$$

A9

$$pp_{mh,l} = pt_{mh,l} + tp_{mh,l} + tc = \left(\frac{WDp_{h,l}}{ex_m} \right)^{e_t} + 0 + 0$$

A10

$$pc_{mh,l} = pt_{mh,l} + tc_{mh,l} + tc = \left(\frac{WDp_{h,l}}{ex_m} \right)^{e_t} + 0 + 0$$

A11

In the LTEM, various domestic producer and consumer support and subsidy measures in the dairy market are incorporated in the price transmission mechanism as ad-valorem distortions[vii] which form a price wedge between domestic and world prices. These measures include direct payments ($sd_{mh,l}$), input subsidies ($si_{mh,l}$), general services expenditures ($sg_{mh,l}$), and other market subsidy payments ($sm_{mh,l}$) to the producers, and a consumer market subsidy ($cm_{mh,l}$). Equations A12 and A13 show the $pp_{mh,l}$ and $pc_{mh,l}$

which are extended with ad-valorem domestic and border policy measures in which *tc* is assumed to be zero. Thus all quantifiable policies affecting dairy prices are included in the equations above.

$$pp_{mh,i} = pt_{mh,i} + tp_{mh,i} + tc + sd_{mi} + si_{mi} + sg_{mi} + sm_{mi}$$

A12

$$pc_{mh,i} = pt_{mh,i} + tc_{mh,i} + tc + cm_{mh,i}$$

A13

The intervention price in the dairy markets is incorporated in the LTEM in the solution procedure through the mathematical MAX function. In the new producer price function, which is respecified in equation A14, the intervention price, $mp_{mh,,l}$, becomes a decision variable and becomes binding if the calculated equilibrium $pp_{mh,l}$ is less than the $mp_{mh,l}$. When $pp_{mh,l}$ is less than $mp_{mh,l}$ the model is pushed to choose $mp_{mh,l}$ as the solution value. If the calculated equilibrium $pp_{mh,l}$ is higher than the $mp_{mh,l}$, then the model continues with the calculated $pp_{mh,l}$ as the solution price level.

$$pp_{mh,i} = MAX((pt_{mh,i} + tp_{mh,i} + tc + sd_{mi} + si_{mi} + sg_{mi} + sm_{mi}), mp_{mh,l}); \qquad tc=0$$

A14

A productivity change, such as an increase in the productivity of maize in a GM adopting country, is reflected through the exogenous change in the shift variable (shf_{qsg}) which is equal to 1 initially. If for example, a 10 percent increase in the production of maize is assumed as a result of a reduction in the use of factors of production, then the shifter becomes equal to 1.00 + 0.10 = 1.10, and causes a parallel downwards shift in the supply curve. As a result, a decrease in the price of GM-maize is expected because of the excess supply created in the domestic market, and this lower price feeds back into the supply function of GM-free maize, as GM and GM-free components are substitutes.

$$qsg_i = a_0 shf_{qsg}\, ppg_i^{a_1}\, pp_i^{a_2} \prod_{j=1}^{2} ppg_j^{a_j}$$

1

The demand for GM grains (oilseeds, maize, wheat and coarsr grains) in the LTEM is disaggregated into feed and food demand. The feed demand for GM maize (for example) is specified as a function of own consumer price, consumer price of GM-free maize, consumer prices of the other substitute GM feed products, and the supply amount of GM raw milk (-subscript *k* is used to denote raw milk). The food demand for GM maize is specified as a function of own consumer price, consumer price of the GM-free maize, consumer prices of the other GM substitutes, per capita real income and population. Similar functional forms and behavioral relationships are also used to reflect the feed and food demand response for GM-free maize, in which the consumer price for GM-maize also appears as a substitute product in consumption to GM-free maize.

Table A1: Country and Commodity[1] Coverage

Countries	*Commodities*	
Argentina-AR	Wheat	Raw milk
Australia-AU	Coarse grains	Liquid milk
Canada-CA	Maize	Butter
European Union (15)-EU	Oilseeds	Cheese
Japan-JP	Oilseed meals	Whole milk powder
Mexico-MX	Oils	Skim milk powder
New Zealand-NZ	Apples	Beef
United States of America-USA	Kiwifruit	Sheepmeat
Rest of World-RW		

[1]: Each commodity is included as GM and GM-free components.

Table A2: Policy Variables/Parameters and Non-Agricultural Exogenous Variables in the Main LTEM Framework

Policy Variables-Domestic Market	*Policy Variables-Border*	*Non-Agricultural Exogenous Variables*
Land set-aside	Import tariff	Gross domestic product
Production quota	Export subsidy	Country price index
Support/minimum price	Trade quota	Population
Producer market subsidy	In-quota tariff	Exchange rate
Producer input subsidies	Out-quota tariff	
Producer direct payments		
Producer general services		
Consumer market subsidy		

[i] See http://members.aol.com/vorecon/vorsim.html.

[ii] In addition, the ability to include agricultural input markets endogenously and to treat commodities as imperfect substitutes (in other words to include bilateral trade relationships) with some effort may make PE frameworks more attractive.

[iii] There are 126 equations for each country and in total there are 2142 equations.

[iv] The list of non-agricultural exogenous variables are given in Table A2.

[v] See Fair (1984) p. 29, Kehoe (1991) p. 2058, and Wooldridge (2002) for more explanation on Newton's global algorithm.

[vi] The demand for other dairy products (qd_{mh}) other than liquid milk is specified by using the same functional form and the same behavioural relationships that are in qd_{ml}.

[vii] As introduced in the methodology of producer and consumer subsidy equivalent (PSE and CSE) measures, Cahill and Legg (1990).