The Cost and Trade Impacts of Environmental Regulations: Effluent Control and the New Zealand Dairy Sector

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Abstract

In New Zealand the Resource Management Act 1991 has put standards in place regarding surface and ground water quality. Nitrogen leaching from dairy effluent compromises these standards; consequently the nation-wide aim is to have all dairy farms operating land-based effluent disposal. An estimate has been made of the cost of this to the New Zealand dairy sector.

An Applied General Equilibrium approach (GTAP) is used to look at the possible impact of these additional production costs on New Zealand's dairy export trade. This analysis is conducted under two scenarios, the first being that New Zealand acts unilaterally in imposing water quality regulations. The second scenario assumes that New Zealand's three main dairy export competitors, the EU, Australia, and the US also enforce their own water quality regulations and internalise the cost of such regulations.

Introduction

The last three decades have seen a growing concern for the deterioration of the natural environment both at the national level and on a global scale. It is acknowledged that different countries have varying assimilative capacities,[2] therefore regulations, standards and the cost to comply with these will also vary. The question is, will these regulatory differences affect international competitiveness?

This paper investigates the impacts of current water quality regulations on the New Zealand dairy sector. The dairy industry is expanding, with dairy exports constituting 20% of total merchandise trade receipts. In recent years, however, concern has grown in New Zealand, and worldwide, regarding the negative environmental impact of intensive dairying, in particular the nitrate levels in ground and surface waters. In New Zealand, both the protection of the environment and trade are important for the economy. This research looks at the possible effects of increased on-farm costs on the competitiveness of the New Zealand dairy sector in the international market.

Environmental regulations can impose costs on polluters. Firms subject to tighter environmental regulations will incur higher costs than firms subject to weaker or non-existent environmental regulations. If two countries were identical in all respects, except for the stringency of their environmental regulations, economic theory would

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[2] Assimilative capacity is measured not only in terms of the ability of the physical environment to absorb waste, but also the level of pollutants that society is willing to tolerate (Bhagwati 1996).

suggest that the country with weak environmental regulations would offer a cost advantage to polluting industries. The extent of the cost advantage will depend on the degree to which the regulations are enforced and how the compliance costs are distributed between the polluters and the rest of society. The overall impact of differing environmental standards, levels of enforcement, and distribution of compliance costs, could cause a change in international competitiveness and lead to changes in the pattern of production and world-wide trade (Anderson and Blackhurst 1992).

"Numerous studies have tried to estimate the impact of environmental control costs (ECC) on industry price and output, and on the trade balance. …The methodologies are quite varied, making comparisons between studies difficult. However, some generalisations can be drawn. First, estimates of total ECC by industry tend to be very low – abatement costs are a very small portion of industry costs on average. Second, reductions in output caused by ECC are also small and insignificant on average, although they can be significant for some individual sectors. Third, there is little evidence of any significant impact of ECC on the pattern of trade" (Dean 1992, 16). Studies by Tobey (1990, 1993), Ratnayake (1996), Ferrantino (1997), and Xu (1998), all conducted within the manufacturing sector, provide no compelling evidence to conclude that environmental standards do lead to loss of competitiveness. Robison's study (1988) measures the impact of marginal changes in industrial pollution abatement (IPA) costs on the United States (US) balance of trade (and balance of trade with Canada in particular) in the period 1973 to 1982. He deliberately assumes full compliance costs are passed through to prices, and his results suggest that marginal changes in IPA will reduce the US balance of trade for most industries. Van Beers and van den Bergh (1997) empirically tested the hypothesis that stringent environmental regulations exert a negative effect on exports and a positive effect on imports. For 'dirty' non-resource based commodities strict environmental regulations did show a significant negative effect on exports, but the hypothesis regarding the effect on imports was rejected.[3]

All of the studies referred to above deal with the manufacturing sector; fewer studies have been conducted to measure the effect on competitiveness of ECC in the agricultural sector. One reason for this is that non-point source environmental damage is more difficult to measure. Another, suggested by Ballenger and Krissoff (1996), is that environmental provisions in agriculture are more often "vague, subject to interpretation, and lacking in concrete policy prescriptions" (Ballenger and Krissoff 1996, 60). Tobey (1991) comments that trade competitiveness losses in agriculture are likely to be modest for three reasons; firstly because most competing exporters among the developed nations have similar agro-environmental programmes. Secondly, developing countries, whose environmental standards are usually less stringent, do not hold a major share in the global export market of most agricultural goods. Finally, any effect on competitiveness is likely to be overshadowed by more significant forces such as movements in exchange rates, shifts in consumer demand for agricultural

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[3] The implication is that governments with relatively strict environmental regulations also have policies in place to impede imports that do not meet domestic environmental standards.

commodities, differences in labour costs, health and safety standards (OECD 1994) and trade policies. Jaffe *et al* (1995) also add to these differences in the cost of energy and raw materials, and strength of the infrastructure, saying that all of these would overwhelm the environmental effect. However, studies by Frandsen and Jacobsen (1999),[4] and Komen and Peerlings (1996)[5] both testing unilateral decisions within the agricultural sector, say that implementation of the environmental regulation would affect agricultural production and the trade balance.

The Case Study
Objectives
The aim of this study is to investigate the impact of current surface and ground water quality regulations on the New Zealand dairy sector. Of interest are the changes made to on-farm practices in order to comply with the water quality regulations. The specific objectives of the research are:
- to estimate the additional production costs required to comply with the regulations, both at the farm level and at the sector level
- to look at the impact of the increase in cost of production on the competitiveness of the New Zealand dairy sector in the international market, under two separate assumptions:
    (i) the decision for full enforcement of water quality regulations is a unilateral decision by New Zealand, and alternatively that;
    (ii) all four principal dairy exporters impose and enforce water quality regulations on their dairy sectors.

Environmental Control Costs
In response to the Resource Management Act 1991 (RMA 1991), Regional Councils throughout New Zealand have required dairy farmers to operate a land-based disposal system for dairy shed effluent. An estimate is made of the additional cost this imposes on dairy farmers. The analysis includes the two main methods of land-based effluent disposal; daily irrigation using a travelling irrigator, and pond storage utilising a tanker to spread effluent onto the pasture two or three times per year. The fertiliser value of the effluent is lower after storage, but this method has the advantage of being able to be used on ground unsuitable for travelling irrigators, and it also allows for irrigation of the effluent when soil conditions are most favourable. In some regions land-based effluent disposal is a permitted activity, whereas in other regions a consent is required with application fees payable.

A number of assumptions have been made in estimating the additional costs. Firstly, that all dairy farms in New Zealand dispose of their dairy shed effluent to land. Secondly, that all dairy farms operate either a travelling irrigator system or pond storage from which effluent is spread, and that the life of both systems is assumed to

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[4] Frandsen and Jacobsen (1999) investigate the economic effect of reducing the use of pesticide in Danish agriculture.
[5] Komen and Peerlings (1996) analyse the effect of the Dutch energy tax introduced in 1996.

be 15 years.[6] Thirdly, consents have been assumed to need renewal after 15 years.[7]
The calculations take into account regional differences in herd sizes and numbers,
consent and monitoring costs,[8] and average annual farm costs (including the
breakdown for wages and capital). Calculations were based on 2 herd sizes, a 150 –
249 cow herd and a 250 – 549 cow herd.[9] Construction and operating costs are given
in Table A1 in the Appendix. Capital costs have been funded by a 15 year loan.

The application of effluent to land has the potential both to reduce the amount of
fertiliser required, and to increase productivity (Parminter 1998). However, there is
uncertainty, and a degree of scepticism about the levels of these.   Therefore a
sensitivity analysis on cost estimations has been conducted, with and without the
inclusion of possible fertiliser and productivity benefits (see Table A1 for these
benefit estimates). Calculations have also been carried out with variations in interest
rates of 7% and 9% for capital cost borrowing.

The total cost for all New Zealand dairy farms to operate a land-based effluent
disposal system was calculated using both methods of disposal (see Table 1). These
costs were then weighted in a 40:60 ratio between the use of irrigators and the pond
storage system. The reason for this is that approximately 60% of NZ dairy farms are
on imperfectly drained soils which are better suited to a storage system where effluent
can be held until the soil is able to absorb the application of effluent. The annual cost
to the New Zealand dairy sector of compliance with water quality regulations lies
between $42.0 million and $67.8 million.

Using the regional dairy farm costs given in Table A2 in the Appendix, the above
compliance costs are then expressed as a percentage of the dairy farmer's total cost.
The compliance cost estimate lies between 2.1% and 3.2% of their total costs[10] (see
Table 1). The additional production costs incurred by disposing of farm dairy effluent
to land, fall into two main areas of a farmer's input costs, namely capital[11] and labour.
The cost of capital equipment is significantly greater for the irrigator system than for
pond storage. However, the reverse is the case for the labour costs associated with the
on-going operation of both systems (refer to Table A1 in the Appendix). Both capital
and unskilled labour costs associated with water quality compliance have been
expressed as a percentage of the dairy farmer's total capital costs and total unskilled
labour costs. These are estimated as 3.2 - 3.6% of capital expenditure, and 19.4 –
19.5% of wages for unskilled workers.[12]

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[6] This estimate is realistic for a travelling irrigator system. However the life of a pond system would be
closer to 30 years, but since the capital cost is relatively small (approximately $4500), it makes little
difference to annual loan payments whether the term of the loan is 15 or 30 years.

[7] In reality this varies from region to region, but has negligible effect on annual loan payments.

[8] Some Regional Councils like Environment Waikato, have used economic incentives to encourage
dairy farmers to discharge effluent onto land while others pass the full cost on to the farmer.

[9] Average herd sizes range from 172 cows in Northland to 487 cows in Waitaki (Livestock
Improvement 1998)

[10] Again a 40:60 weighting was used between the use of irrigators and the pond storage system.

[11] Also included in capital are consent costs, since these have been financed within the loan.

[12] The percentage of capital and unskilled labour costs attributable to water quality compliance can be
found in Table 2. For final figures the 40:60 weighting was used.

The Trade Effect
An applied general equilibrium (AGE) approach is used to analyse the possible impact that additional production costs incurred by the New Zealand dairy sector in complying with water quality regulations, have on New Zealand's dairy export trade. The aim is to use a computable general equilibrium (CGE) model to give a 'broad brush' interpretation of the probable effects of these increased dairy costs on the overall competitiveness of the New Zealand dairy export sector in the world market. The aim is also to show any effect on the reallocation of resources to other sectors, and on welfare.

The CGE model used is the Global Trade Analysis Project (GTAP) (Hertel 1997), which makes use of comprehensive data on international industry and policy to investigate market (in particular trade) consequences of environmental policy. The GTAP model does not incorporate environmental externalities. This means that it does not measure the benefit to society of cleaner surface and ground water, or the cost to individuals of having to purify their own water in the absence of these environmental policy measures.

GTAP is a relatively standard, multi-region model. Its data base divides the world economy up into 50 sectors (20 are agricultural or processed foods) and 45 countries or country groups. The aggregations of commodity and regional groupings used in this study are given in Table A2 in the Appendix. Regional data bases are derived from individual country input-output tables, based on the year 1995, and provide the framework for the GTAP model. The data base consists of bilateral trade, transport, and protection matrices that link the regional economic data bases.

There are a number of assumptions made by the model that are relevant to this study. The choice of inputs used by a firm to produce its output hinges on assumptions made about separability in production. It is assumed that the optimal combination of primary factors adopted by the firm is independent of the prices of the intermediate inputs. Constant returns to scale is also assumed, leaving only the relative prices of land, labour, and capital as arguments in the firms' conditional demand equations for components of value-added. Furthermore, the assumed separability is symmetric, meaning that the combination of intermediate inputs is also independent of the prices of primary factors (Hertel and Tsigas 1997). The model uses constant elasticity of substitution (CES) derived demand equations. Non-substitution between composite intermediate inputs and primary factors is a further restriction imposed in this study. The justification being that while there is possible substitutability between some intermediate inputs and primary factors, this is not the case for all intermediate inputs. GTAP adopts the 'Armington approach'[13] to modelling trade. The assumption here is that commodities, which are domestically produced and used, are not perfect substitutes for those goods that are imported and exported.

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[13] First put forward by Paul Armington in 1969.

Experiments

Two experiments are carried out to look at the impact of the increase in cost of production on the competitiveness of the New Zealand dairy sector in the international market, under two separate assumptions. Experiment One assumes that the decision for full enforcement of water quality regulations is a unilateral decision by New Zealand. Experiment Two, on the other hand, assumes that all four principal dairy exporters (the European Union (EU), New Zealand, Australia and the US) impose and enforce water quality regulations on their dairy sectors. A further assumption in both experiments is that no environmental regulations are imposed on the other sectors of these countries.

Regulations pertaining to water quality have required dairy farms in New Zealand to adopt a land-based disposal system for dairy shed effluent. The adoption of such systems impacts primarily on a dairy farmer's capital and unskilled labour costs. For this reason the cost of compliance with environmental policy standards was disaggregated into these two components. As the GTAP data base used in this analysis is based on 1995 data, it is necessary to use 1995 data for compliance costs for the New Zealand dairy sector. It is estimated that approximately half of the dairy farms in New Zealand were operating land-based effluent disposal systems by 1995. Therefore it is realistic to suggest that as a direct result of environmental policy measures implemented in response to the RMA 1991, capital costs and wages in the New Zealand milk producing sector could increase after 1995 by as much as 1.8% and 9.75% respectively.[14] If the milk production sector continues to operate with the same level of primary factor input, then productivity in terms of milk output would decline. This is clear since some factors of production are now being diverted into ensuring that the dairy farm is meeting water quality standards. For milk output to be maintained in the face of the new regulations, more resources must flow out of other sectors and into milk production.

A way of simulating this reduction in productivity would be to shock the variable *AFE* (primary factor-augmenting technical change). This would require $afe(i,j,r) < 0$, where *afe* represents a percentage change in the variable *AFE*, so that the effective price of primary factor *i*, increases. This will result in some substitution of other primary inputs for factor *i*. But the reduced productivity of *i* will also mean an increase in the demand for *i,* and a rise in the cost of the value-added composite. Therefore the first experiment conducted will be to proxy these two primary factor cost increases with shocks to two technical change variables within the New Zealand milk-producing sector. One is a capital-augmenting technical change, and the other an unskilled labour-augmenting technical change and both will experience the relevant percentage change shock. The upper end of the cost estimates will be used to represent a worst case scenario, and the *afe* shocks will need to be negative. The two shocks, then, will be:

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[14] These figures are obtained by halving the upper end of the capital and wage consent cost estimates, which are calculated using the higher interest rate and also ignoring any possible fertiliser and productivity benefits of land-based effluent disposal.

afe(capital, milk, NZ) = -1.8
afe(unskilled labour, milk, NZ) = -9.75.

The three other principal dairy exporters have also been addressing environmental issues this past decade and implementing their own regulations regarding ground and surface water quality. Therefore Experiment Two examines trade impacts where all four principal dairy exporters impose and enforce water quality regulations on their dairy sectors. In this experiment a shock is applied to the milk producing sector of each of the four regions. Data comparable to that for New Zealand was not available from the other three principal dairy exporting regions. However the best available estimates of compliance costs for these regions have been used. There are also no figures available regarding the percentage of dairy farms in the EU, Australia, or the US, which were complying with the relevant standards or regulations by 1995. Each of these regions has a dairy sector that receives a significant level of economic assistance from the government[15] and so these sectors are not carrying their full costs. Furthermore, in the US and EU financial assistance is given to farmers for environmental purposes.[16] This means that the additional production costs to the farmer are not as great as they would have been without government subsidies. With a lower increase in on-farm production costs, there will be a smaller reduction in the output of milk and processed dairy products. However, when compliance costs are incorporated into the model, it makes the assumption that the full incidence of these costs is borne by the producers. Therefore in order to make this analysis more realistic, the upper bound cost estimates for the EU, Australia, and the US have been halved and the relevant shocks applied.

In the US, compliance cost estimates vary between states and with herd size. Use has been made of Heimlich and Barnard's (1995) extensive study and their finding that 80% of farms had compliance costs that were less than 10% of their total costs. Again the upper bound approach will be taken and 10% will be used as the estimate for the US. This study does not provide a break down of the costs in terms of primary factor inputs as we have for New Zealand. For this reason it will be necessary to proxy this overall cost of production increase by an output-augmenting technical change (variable *AO*) which will be half the upper bound compliance cost. This will mean a negative shock to *ao* (the variable representing a percentage change in *AO*), so that the input requirements for producing a given level of output are uniformly increased. The shock used is:

ao(milk, USA) = -5

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[15] The 1998 provisional figures for the PSE for milk production is 0% for New Zealand, 31% for Australia, 57% for the EU, and 61% for the US (OECD 1999).

[16] In the US this is done through the Environmental Quality Incentives Program (EQIP). In 1997 and 1998 approximately 54% of EQIP funding was given for addressing animal waste problems (NASDA 1998).

The densely populated countries of the EU face serious problems with the disposal of animal effluent in regions where farming is intensive and animals are confined for certain periods of the year. Furthermore, the EU has stringent standards in place to protect both surface and ground waters against nitrate contamination from agricultural sources. There is no available estimate of the cost to the farmer of meeting the standards outlined in the Nitrate Directive of 1991 for the EU. However, it was estimated by Leuck *et al* (1995) that the effect of full implementation of the Nitrate Directive to achieve the nitrogen maximum annual residual (MAR) allowed by the Directive would reduce the number of dairy livestock in the EU by 7.8%.[17] Experiment Two uses their result, halving its magnitude (for the same reason as the cost estimates have been halved). It is assumed that a 3.9% reduction in livestock will reduce milk output by 3.9%. In the model this would be represented by a negative shock to quantity of output, *QO*. This is carried out using variable *qo*, which represents a percentage change to QO and the shock used is:

$$qo(milk, EU) = -3.9$$

In the standard GTAP closure, *QO* for produced commodities is an endogenous variable. Now in order to carry out this shock, *QO(milk, EU)* must be made exogenous and *AO(milk, EU)* is endogenised. The solution will give the equivalent *ao* shock that would result in a reduction in milk output of 3.9%.

Australia grazes its cattle outdoors, has low stocking rates and low rainfall. Also the continent's population density is extremely low and as a consequence Australia does not face the same water contamination problems as North America or the EU. The magnitude of its environmental concerns, and hence its potential water quality compliance costs, could in the future, equate more closely with those for New Zealand than for either the US or the EU. Since there are no available estimates for compliance costs for the Australian milk-producing sector, these have been approximated by the total cost estimates for the New Zealand milk sector. The upper bound of 3.2% of total cost will be used as an estimate of compliance costs for Australia. The shock used will be a negative, output-augmenting technical change shock to Australia's milk production sector of:

$$ao (milk, Australia) = -1.6$$

The shocks to the New Zealand milk-producing sector in the second experiment are the same as those used in Experiment One.

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[17] The Nitrate Directive impacts not only on dairy production, but also on all livestock production and cropping. To achieve the nitrogen MAR, output of all livestock will decrease (the extent will depend on the livestock type). This will also mean a reduction in related outputs like wool, meats, and other processed foods. The Directive also effectively restricts the use of inorganic fertiliser used for pasture and for cropping, which will in turn affect other crops, grain, and other processed foods. This study restricts its investigation to the impact of environmental regulations on only the dairy sector of each of the four regions.

Finally, a sensitivity analysis was carried out for Experiment Two, by halving the size of the shocks to the other three regions. Interest is primarily in the direction (more than in the magnitude) of any changes taking place within the New Zealand dairy sector as a result of shocks to the dairy sector of each of the other main dairy exporting regions. Therefore the intention of the sensitivity analysis is to verify the direction of any changes taking place within the New Zealand dairy sector.

Results

Of interest are the impacts on New Zealand of the different scenarios presented in these two experiments. For this reason only results for New Zealand are discussed.

Experiment 1 is the situation in which only New Zealand has real costs imposed on its dairy sector as a consequence of environmental standards imposed to improve surface and ground water quality. As a result New Zealand's volume of milk output and processed dairy products is reduced by 3.3% and 4.6% respectively (see Table 3). The negative productivity shock to the milk production sector results in a contraction of this sector relative to other sectors. More capital and unskilled labour is now required for every litre of milk produced. The demand for unskilled labour in the milk producing sector rises by 6% despite the 3.3% drop in the volume of milk produced. To meet that rise in demand for unskilled labour there is a small shift of unskilled labour (of less than 0.5%) out of most other production sectors. New Zealand's supply price of milk and processed dairy products rises by 3.2% and 1.6% respectively (Table 3). However price changes in New Zealand have no impact on the world price index for milk and only minimal impact on the global dairy export price index. As a result New Zealand experiences a reduction in the overall quantity of dairy exports to all destinations of 4.7 – 6.3% (refer to Table 4). The total value of New Zealand's dairy exports falls by more than 4% (Table 3).[18] As a result of the above, New Zealand suffers a decline in welfare. However, this could be negated by the positive welfare effect as a result of improved surface and ground water quality, which is not included in this welfare measure.

Experiment Two is the scenario where each of the four principal dairy exporting regions has water quality standards imposed that mean real cost to the dairy sector of each region. The EU has 45% of the world dairy export market. Therefore it is the shock to reduce total milk output in the EU by 3.9% which has the greatest impact on all four principal dairy exporting regions. With milk output down by nearly 4%, the volume of dairy products produced in the EU falls by 6%. Domestic demand for dairy products falls by only 3%, so clearly the exportable surplus of dairy products from the EU is reduced. Also dairy products produced in the EU experience a price rise of 16.6%. The other dairy exporters also experience an increase in the price (fob) of their dairy exports, but this is by only 1.6 to 3.2%. Therefore there is an increase of the world price index for total supply of dairy products by almost 9%. Also the global dairy export price index rises by 13% (refer to Table 3). The EU experiences a price increase for dairy exports at least five times larger than the percentage increases

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[18] This is in line with the findings by Frandsen and Jacobsen (1999), and Komen and Peerlings (1996).

experienced by her competitors. This causes the EU to lose market share to the other principal dairy exporters. Table 5 shows the reduction of the EU's dairy exports everywhere by at least 30%, and by as much as 38.5% to Northeast Asia.

New Zealand, with a much smaller supply price rise for both milk and dairy products than in the world market is able to expand production and increase exports. The volume of milk and processed dairy product output rises by 8% and 12% respectively (Table 3). This, combined with a reduction in productivity in New Zealand's milk sector means a shift of resources into these two sectors (primarily from other crops and sheep production). The model predicts a substantial increase in the quantity of processed dairy exports from the New Zealand to all export destinations, from a 2.8% increase to Northeast Asia, to a 57.5% increase to the EU (Table 5). Consequently the value of New Zealand dairy exports increases by 19% (Table 3). New Zealand GDP and household income rises and there is a positive effect on welfare (see Table 3), quite apart from the improvement in welfare brought about by improved water quality. The sensitivity analysis confirms the direction of the changes as a result of the shocks imposed in Experiment Two.

Conclusions

The aim of this research was twofold. Firstly, it was to estimate the additional production costs required to comply with water quality regulations for the New Zealand dairy industry. Secondly, it was to examine the impact of this increase on the cost of production on the competitiveness of the dairy sector in the international market.

It was found that environmental control costs are a relatively small portion of the industry's total production costs at 2.1 – 3.2%, which matches Dean's observations (1992).

The examination of the trade impact of these environmental control costs was examined under two separate scenarios. In the case that New Zealand would unilaterally impose these costs on its industry, the CGE model predicts that the result would be a reduction of the volume of New Zealand's dairy exports to all destinations and a decline in total value of the dairy exports. This indicates a potential loss of competitiveness for New Zealand in the global dairy market and a loss in welfare. In the second scenario ECC are imposed on dairy farmers in all four principal dairy exporting regions. In this case the model predicts that the EU will reduce the quantity of dairy products produced and exported. The price of the EU's dairy products will increase relative to the other main dairy exporters, and the EU will lose global market share. There will be a gain in competitiveness for New Zealand in the global dairy market and an increase in welfare.

The results show that the trade impacts could be significant. These results, however, are dependent especially on the way the ECC are distributed between farmers and the rest of society in each of the four countries. With substantial 'aid' in the form of subsidies, grants, tax write-offs etc in other countries (none of which exist in New

Zealand), the actual situation could be closer to Experiment One than Experiment Two. Without those 'aids' the situation will be in the direction of Experiment Two showing the results of New Zealand's competitive advantage due to a favourable environmental situation and climate for dairying.

The analysis highlights shortcomings both in the data, and in the CGE model used. By using a CGE model in which countries are linked through trade flows it is possible to examine the broader effects in the issue of competitiveness and the interactions between different sectors and countries. However results are likely to be sensitive to the assumptions adopted by the model. Furthermore, outcomes are impeded by the fact that the GTAP model does not incorporate environmental externalities, nor measure the benefit to society of improved water quality.

The other main difficulty was the lack of comparable data on the impacts of water quality regulations for the regions included in this study. Estimates of compliance costs were not available for Australia. For both the EU and the US (aggregated as such in GTAP), each region covers a large number of countries or states. The geographical size of each region means huge differences in climatic conditions, soil types and farming practices. The task of calculating compliance costs is vast and varied. Since comprehensive data was not available a number of assumptions and approximations had to be made. These shortcomings give rise to suggestions for further research.

Clearly further research into compliance costs for water quality regulations is required in the other three principal dairy exporting regions.

Water quality, even though of major importance, is only part of the overall bundle of environmental regulations relevant to dairy production. More detailed research is required on the relative impact of the full range of environmental regulations in the major dairy exporting regions.

Also the investigation was limited to the impact of water quality regulations on the dairy sector. These water quality regulations will impact not only on dairy production, but also on all livestock production, as well as on cropping (and indirectly on wool, meats and other processed food). If data were collected for changes in production costs, or levels of output in these sectors, a more comprehensive general equilibrium analysis could be carried out. This would give a better indication of the trade impacts of specific environmental regulations.

Finally, work needs to be done to incorporate environmental externalities into CGE models like GTAP as "the absence of environmental features in GTAP complicates the process of analysing environmental policy" (Perroni and Wigle 1997, 306). Environmental policy is likely to see increased production costs through the addition of compliance costs, but with existing CGE models there is no measure of the benefit brought about by improved environmental quality, leaving the analysis incomplete.

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Table 1   Costs of Regulatory Compliance

Compliance Costs	Travelling Irrigator[1]	Pond Storage
National Net Cost ($million) - annual benefits included	24.4[2] (29.15)	53.8 (54.8)
National Cost ($million) - excluding annual benefits	53.35 (58.2)	73.2 (74.2)
National Net Cost (% total farm costs) - annual benefits included	0.70% (0.84%)	3.05% (3.11%)
National Cost (% of total farm costs) - excluding annual benefits	1.53% (1.67%)	4.14% (4.19%)

[1] Costs given for the Travelling Irrigator system are taken as the average of the costs calculated for the irrigator system on flat to rolling pasture and more hilly pasture.
[2] Front figures calculated using an interest rate of 7%, figures in parentheses have been calculated using a 9% interest rate.

Table 2   Percentage of Costs Attributable to Water Quality Compliance

	Travelling Irrigator[1]	Pond Storage
Percentage of Capital Costs	6.04%[2] (6.63%)	1.38% (1.52%)
Percentage of Unskilled Labour Costs	4.50% (4.72%)	29.27%

[1] Costs given for the Travelling Irrigator system are taken as the average of the costs calculated for the irrigator system on flat to rolling pasture and more hilly pasture.
[2] Front figures have been calculated using an interest rate of 7%, figures in parentheses have been calculated using a 9% interest rate.

Table 3　**Comparison of the Percentage Change[19] of a number of Variables across the two Experiments**

Variable	Experiment 1	Experiment 2
Milk: NZ quantity output (qo)	-3.3	8.3
Milk: NZ supply price (ps)	3.2	5.6
Dairy products: NZ quantity output (qo)	-4.6	12.1
Dairy products: NZ supply price (ps)	1.6	3.2
Dairy products: world price index for total supply (pw)	0.0	8.9
Dairy exports: global export price index ($pxwcom$)	0.1	13.1
Value of NZ's dairy exports ($vxwfob$)	-4.3	19.1
Value of NZ's GDP ($vgdp$)	-0.1	0.5
NZ's Welfare - $US million ($EV$)	-$53	$106

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[19] Actual change for the welfare measure.

Table 4   Effect on the Quantity of Export Sales of Dairy Products from the Principal Dairy Exporters (% change) – *qxs*
Experiment One

Destination: Exporter:	NZ	Australia	EU	USA	Canada	NE Asia	SE Asia	Central America	Russia	ROW
NZ		-4.7	-6.2	-6.3	-6.2	-5.7	-5.2	-5.9	-5.9	-6.2
Australia	2.8		0.0	0.1	0.3	0.8	1.3	0.6	0.5	0.2
EU	2.9	1.8		0.2	0.3	0.8	1.4	0.7	0.6	0.3
USA	2.9	1.8	0.1		0.4	0.9	1.4	0.7	0.6	0.3

Table 5   Effect on the Quantity of Export Sales of Dairy Products from the Principal Dairy Exporters (% change) – *qxs*
Experiment Two

Destination: Exporter:	NZ	Australia	EU	USA	Canada	NE Asia	SE Asia	Central America	Russia	ROW
NZ		6.6	57.5	13.2	4.1	2.8	6.1	12.4	13.9	10.6
Australia	10.6		67.8	20.9	11.4	9.8	13.5	20.1	22.2	18.2
EU	-37.3	-36.0		-32.0	-37.4	-38.5	-36.5	-32.5	-30.4	-33.2
USA	8.0	11.2	63.9		9.0	7.4	10.5	17.5	17.6	15.3

Appendix

Table A1   Costs and possible benefits of land-based effluent disposal

	Travelling Irrigator	Pond Storage System
Construction Costs[1] ($)	18,000[3] (25,000)	4,500 (4,500)
Annual Operating Costs[2] ($)	1,000 (1,450)	3,900 (7,000)
Possible Annual Fertiliser and Productivity Benefits	1,800 (3,150)	1,200 (2,100)

[1] Construction costs for a travelling irrigator system increases by $8,000 for both herd sizes on more hilly terrain.
[2] Operating costs for a travelling irrigator system increases by $400 for both herd sizes due to increase in repairs and maintenance, on more hilly terrain.
[3] Front figures calculated for a herd size of 150–249 cows, figures in parentheses have been calculated for a 150–549 cow herd.

Note: Costs are based on 1998 estimates from the Waikato Region, and have been rounded to the nearest thousand.

Source: Parminter 1998.

Table A2   Regional Dairy Farm Costs (calculated in $, per head of cow)

Region	Total Cost[1]	Capital Cost[2]	Unskilled Labour(wages)
Northland[3]	868	156	15
Waikato/South Auckland[3]	1062	193	62
Bay of Plenty[3]	1111	192	40
Taranaki	1110	246	59
Southern North Island	1039	219	35
West Coast/Nelson	1036	303	87
Canterbury	1174	291	124
Southland	1272	297	92

[1]Total Cost   =   cash farm expenditure + personal drawings + tax + interest + principal repayment + capital purchases
[2]Capital   =   principal repayment + interest + capital purchases

[3]These figures are reliable projections from previous years

Source: MAF National Farm Monitoring Summary 1999.

Table A3   Region and Commodity Aggregations for GTAP used in this study

Regions:	Commodity categories used:
NZ	Milk
Australia	Dairy products
EU	Other crops
USA	Grains
Canada	Other livestock
NE Asia	Wool
SE Asia	Forestry
Russia	Meats other processed food
Central America	Manufacturing & services
ROW	Capital goods commodities