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Cost and trade impacts of environmental regulations: effluent control and the New Zealand dairy sector†

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New Zealand legislation sets standards for water quality. Nitrogen leaching from dairy effluent compromises these standards, with the consequent move being toward land-based effluent disposal. The cost of this to the dairy sector was estimated and a Computable General Equilibrium (CGE) model (GTAP) was used to investigate the impact of additional production costs on NZ's dairy export trade. Two scenarios were analysed: first, NZ acts unilaterally in imposing water quality regulations, second, the other principal dairy exporters act in a similar fashion. Changes in trade patterns vary from insignificant to large, depending on the scenario analysed.

1. Introduction

The latter half of last century saw a tremendous increase in global economic activity as a result of population and per capita income growth. Accompanying this economic activity has been the growing deterioration of the natural environment (Nordström and Vaughan 1999). By the late 1960s and early 1970s the level of environmental degradation had become a focus of concern, both at the national level and on a global scale. As a result, many countries have put in place regulations and standards affecting economic activity where it is directly harmful to the environment. It is acknowledged that different countries have varying assimilative capacities, both in terms of the ability of the physical environment to absorb waste, and also the level of pollutants that society is willing to tolerate (Bhagwati 1996). Therefore, environmental regulations, standards, and the cost of complying with these will also vary. The

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question is, will these regulatory differences affect the relative cost of production between countries and international competitiveness?

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 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. If producers are subsidised for the cost of meeting those regulations, the effect on the level of production will be less than if the producer bore the full cost of environmental compliance. The overall impact of differing environmental standards, levels of enforcement, and the 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).

This article investigates the impacts of current water quality regulations on the New Zealand (NZ) dairy sector. The dairy industry is expanding, with dairy exports constituting 20 per cent of total merchandise trade receipts. In recent years, however, there has been increasing concern in NZ and world-wide, over the negative environmental impact that intensive dairying has, in particular on the nitrate levels in ground and surface waters. Dairy farmers in NZ have been required to move toward land-based effluent disposal systems in order to reduce these nitrate levels. Implementing such a system increases on-farm costs. In NZ, both trade and the protection of the environment are important for the economy. This research looks at the possible effect these increased on-farm costs have on the competitiveness of the NZ dairy sector in the international market.

The next section presents the findings of a number of earlier studies, which also investigated the trade implications of environmental regulations. Then the approach taken by the NZ dairy sector to improve nitrate levels in surface and groundwater arising from farm dairy effluent disposal is discussed. The resulting additional on-farm costs are estimated. Finally, the possible trade impacts of this increase in the cost of production to the NZ dairy sector are assessed.

2. Observations from the literature

Dean (1992, p. 16) observes that:

> 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.

Studies by Tobey (1990, 1993), Ratnayake (1996), Ferrantino (1997), and Xu (1998), were all conducted within the manufacturing sector and provide no compelling evidence to conclude that environmental standards do lead to loss of competitiveness. Robison (1988) used a partial equilibrium framework to assess the impact of marginal changes in industrial pollution abatement costs on the US balance of trade (and in particular, the balance of trade with Canada). He deliberately assumed full compliance costs were passed through to prices, and his results suggested that marginal changes in industrial pollution abatement would 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.[1]

All 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 reason suggested by Ballenger and Krissoff (1996, p. 60), is that environmental provisions in agriculture are more often 'vague, subject to interpretation, and lacking in concrete policy prescriptions'. Tobey (1991) comments that trade competitiveness losses in agriculture are likely to be modest for three reasons. First, most competing exporters among the developed nations have similar agro-environmental programmes. Second, developing countries, whose environmental standards are usually less stringent, do not have 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 commodities, differences in labour costs, health and safety standards (OECD 1994), and trade policies. Jaffe *et al.* (1995) add to these differences in the cost

[1] 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.

of energy and raw materials, and strength of the infrastructure, by saying that all of these would overwhelm the environmental effect. However, studies by Frandsen and Jacobsen (1999),[2] and Komen and Peerlings (1996),[3] both using general equilibrium models and testing unilateral decisions within the agricultural sector, say that implementation of environmental regulations would affect agricultural production and the trade balance.

3. Environmental control costs for the NZ dairy sector

In NZ, discharges to water or land have become subject to the requirements of the Resource Management Act 1991 (RMA 1991). Under the Act, discharges to water are allowed only where a consent has been issued by the relevant Regional Council.[4] Discharge of effluent to land also requires a consent unless it has been made a permitted activity which can be done as of right, given adherence to provisions made for this in the regional plan. Regional Councils have required dairy farmers to move toward a land-based disposal system for dairy-shed effluent.[5] This requirement is in line with the desire to maintain or improve surface and groundwater quality, especially in the main dairying regions.

The land-based effluent disposal options considered for this study are: daily irrigation using a travelling irrigator, and pond storage utilising a tanker to spread effluent onto pasture two or three times a year. With pond storage, the fertiliser value of the effluent is lower, but it does offer greater flexibility with regard to terrain and also the timing of effluent application. This method can be used on ground unsuitable for travelling irrigators, and spraying can take place when soil conditions are most favourable.

The introduction of new effluent disposal systems implies on-farm capital, operating, and consent costs.[6] The total cost to introduce new effluent

[2] Frandsen and Jacobsen (1999) investigate the economic effect of reducing the use of pesticide in Danish agriculture.

[3] Komen and Peerlings (1996) analyse the effect of the Dutch energy tax introduced in 1996.

[4] In some instances they can be specifically permitted in a regional plan.

[5] The majority of Regional Councils now treat the discharge of dairy effluent to land as a command and control regulation, but there are still several regions for which this is not the case. This research has assumed that discharge of effluent to land is a command and control regulation for all NZ dairy farms.

[6] Consent costs vary from region to region. In regions where land-based effluent disposal requires a consent, there is an associated application fee, but where it is a permitted activity, no fee is required. In most regions monitoring costs are passed on to the farmer.

disposal systems is estimated below, both for the farm and at the sector level. A number of assumptions were made in estimating the additional costs. First, all dairy farms in NZ must dispose of their dairy-shed effluent to land. Second, all dairy farms operate either a travelling irrigator system or pond storage from which effluent is spread, and the life of both systems is 15 years.[7] Third, consents have been assumed to need renewal after 15 years.[8] The calculations take into account regional differences in herd sizes and numbers, consent and monitoring costs, and average annual farm costs (including the breakdown for wages and capital).[9] Calculations were based on two herd sizes, a 150–249 cow herd and a 250–549 cow herd.[10] 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 level of these effects. Therefore, a sensitivity analysis on cost estimations has been conducted, with and without the inclusion of possible fertiliser and productivity benefits.[11] Calculations have also been carried out with variations in interest rates, 7 per cent and 9 per cent, for the cost of borrowed capital.

The total cost for all NZ 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

[7] 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.

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

[9] Regional farm costs, and construction and operating costs of effluent disposal systems are available from the authors on request.

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

[11] Raw effluent has been estimated to contain 10.4g/cow/day of nitrogen, 1.7 6g/cow/day of phosphorus, and 8 g/cow/day of potassium (Vanderholm 1984). The value of the equivalent quantity of fertiliser has been estimated at $218/ha. Land application of farm dairy effluent may improve grass production since it applies a greater quantity of some nutrients than the standard fertiliser programme used. This in turn could improve dairy production and returns. The combined annual benefit of saved fertiliser costs and suggested production benefits have been estimated for a 150–249 cow herd at approximately $1800 for fresh effluent systems and $1200 for stored effluent systems. To achieve the acceptable level of 150 kg of nitrogen per hectare in a season, an area of 6.35 hectare would need to be irrigated with effluent (Parminter 1998). Further details regarding calculation of fertiliser and productivity benefits are available from the authors on request.

Table 1 Costs of regulatory compliance

Compliance costs	Travelling irrigator [a]	Pond storage
annual net national cost ($NZ million) fertiliser and productivity benefits included	27.3 [b] (32.1)	53.8 (54.8)
annual national cost ($NZ million) excluding fertiliser and productivity benefits	56.3 (61.2)	73.2 (74.2)
net national cost (% of total farm costs) fertiliser and productivity benefits included	0.78% (0.92%)	3.05% (3.11%)
national cost (% of total farm costs) excluding fertiliser and productivity benefits	1.61% (1.7%)	4.14% (4.19%)

Notes:
[a] 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.
[b] Front figures calculated using an interest rate of 7 per cent, figures in parentheses have been calculated using a 9 per cent interest rate.

and the pond storage system. The reason for this is that approximately 60 per cent 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. Therefore the annual cost to the NZ dairy sector of compliance with water quality regulations lies between $NZ43.2 million and $NZ69.0 million.[12] Using the regional dairy farm costs, 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 per cent and 3.2 per cent of total costs[13] (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[14] 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. Both capital and unskilled labour costs associated with water quality compliance have been expressed as a percentage of the dairy farmer's

[12] $NZ43.2 million was obtained using an interest rate of 7 per cent and including fertiliser and productivity benefits, while the upper figure of $NZ69.0 million was obtained using a 9 per cent interest rate and excluding fertiliser and productivity benefits.

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

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

Table 2 Percentage of costs attributable to water quality compliance

	Travelling irrigator [a]	Pond storage
Percentage of capital costs	6.04 [b] (6.63)	1.38 (1.52)
Percentage of unskilled labour costs	4.50 (4.72)	29.27 [c]

Notes:
[a] 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.
[b] Front figures have been calculated using an interest rate of 7 per cent, figures in parentheses have been calculated using a 9 per cent interest rate.
[c] Construction costs for the pond storage system were not broken down into labour costs and cost of materials, consequently, labour costs here apply only to the annual operating costs, therefore variation in interest rate is not relevant.

total capital costs and total unskilled labour costs. These are estimated as 3.2 to 3.6 per cent of capital expenditure, and 19.4 to 19.5 per cent of wages for unskilled workers[15] (see table 2).

4. The trade effect

Increasing on-farm costs (due to the required installation of new effluent disposal systems) increases the cost structure of dairy farming in NZ. This may impact on the competitiveness of the NZ dairy sector in the international market. To determine the possible effect on competitiveness, two separate alternative scenarios were analysed:

(a) the decision for full enforcement of water quality regulations is a unilateral decision by NZ;
(b) all four principal dairy exporters impose and enforce water quality regulations on their dairy sectors.

4.1 Methodology

A CGE model was used to analyse the possible impact that additional production costs incurred by the NZ dairy sector in complying with water quality regulations have on NZ's dairy export trade. The aim was to give a 'broad brush' interpretation of the probable effects of these increased dairy costs on the overall competitiveness of the NZ dairy export sector in the world market. Reallocation of resources to other sectors and the effect on welfare were observed.

The CGE model used was the Global Trade Analysis Project (GTAP) (Hertel 1997) which makes use of comprehensive data on international

[15] For final figures, the 40:60 weighting between the two systems was used.

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 benefits to society of cleaner surface and groundwater, or the cost to individuals to purify their own water in the absence of these environmental policy measures.

GTAP is a relatively standard, multi-region model. Its database divides the world economy 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 Appendix table A1. Regional databases are derived from individual country input–output tables based on the year 1995, and provide the framework for the GTAP model. The database consists of bilateral trade, transport, and protection matrices that link the regional economic databases.[16]

There are a number of assumptions made in 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 are 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-derived demand equations. Non-substitution between composite intermediate inputs and primary factors is a further restriction imposed in this study. The justification for this assumption is 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' to modelling trade; that is, commodities which are domestically produced and used are not perfect substitutes for those goods that are imported and exported.

4.2 Experiments

Two experiments were conducted to look at the impact of the increase in cost of production on the competitiveness of the NZ dairy sector in the international market. Experiment 1 assumed that the decision for full

[16] Export subsidies for all regions have been modelled and domestic supports are captured between market and producer prices. The EU has some complicated market access policies. Tariff Rate Quotas (TRQs) on dairy produce are not modelled explicitly, but GTAP does incorporate the applied equivalent tariffs in the base year (1995).

enforcement of water quality regulations was a unilateral decision made by NZ. Experiment 2, on the other hand, assumed that all four principal dairy exporters (the European Union (EU), NZ, Australia and the United States) imposed and enforced water quality regulations on their dairy sectors. A further assumption in both experiments was that no new environmental regulations were imposed on any of the production sectors in these regions.

Regulations pertaining to water quality have required dairy farms in NZ to adopt a land-based disposal system for dairy-shed effluent. The adoption of such systems impacts primarily on a dairy farm's capital and unskilled labour costs. For this reason, the cost of compliance with environmental policy was disaggregated into these two components. As the GTAP database used in this analysis is based on 1995 data, it was necessary to use 1995 data for compliance costs for the NZ dairy sector. It was estimated that approximately half the dairy farms in NZ 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 NZ milk-producing sector may increase after 1995 by as much as 1.8 per cent and 9.75 per cent, respectively.[17] If the milk production sector continued 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 is to shock the primary factor-augmenting technical change variable (*AFE*) in the GTAP model.[18] 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 proxied the two primary factor cost increases incurred by NZ milk producers. This was done with shocks to both the capital-augmenting, and the unskilled labour-augmenting technical change variables within the NZ milk production sector. The upper end of the cost estimates was used to

[17] These figures were obtained by halving the upper estimate of capital and wage consent costs, calculated using the 9 per cent interest rate and ignoring possible fertiliser and productivity benefits.

[18] The relevant equation is affected by a shock to the variable AFE is equation (34) in Table 2.11, Hertel and Tsigas (1997, p. 42). The notation used in the equation can be found in Hertel (1997, pp. 371–96).

represent a worst-case scenario, and the *afe* shocks were made negative to reflect the reduction in productivity. Thus the two shocks used were:

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

The three other principal dairy exporters have also been addressing environmental issues and implementing their own regulations regarding ground and surface water quality. Therefore experiment 2 examined trade impacts where all four principal dairy exporters impose and enforce water quality regulations on their own dairy sectors. In this experiment a shock was applied to the milk production sector of each of the four regions. Data comparable to that for NZ were 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 United States 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;[19] these sectors are therefore not carrying their full costs. Furthermore, in the United States and EU, financial assistance is given to farmers for environmental purposes.[20] 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 were incorporated into the model, the assumption was made that the full incidence of these costs was borne by the producers.[21] Therefore in order to make this analysis more realistic, the upper bound cost estimates for the EU, Australia, and the United States were halved and the relevant shocks applied.

In the United States, compliance cost estimates vary between states and with herd size. Use was made of Heimlich and Barnard's (1995) finding that

[19] The 1998 provisional figures for the PSE for milk production is 0 per cent for NZ, 31 per cent for Australia, 57 per cent for the EU, and 61 per cent for the United States (OECD 1999).

[20] In the United States, this is done through the Environmental Quality Incentives Program (EQIP). In 1997 and 1998 approximately 54 per cent of EQIP funding was given for addressing animal waste problems (NASDA 1998).

[21] The results show an increase in producer prices for milk and dairy products. However, it is also observed that the market prices for these goods have increased and some factor prices are up, indicating that some of these increased producer costs are passed on to other agents.

80 per cent of US farms had compliance costs that were less than 10 per cent of their total costs. The upper bound of 10 per cent of total costs was used as the estimate for compliance costs for the United States. Heimlich and Barnard did not provide a breakdown of the costs in terms of primary factor inputs as we have for NZ. Therefore it was necessary to proxy this overall cost of production increase by an output-augmenting technical change (variable *AO*) which was half the upper bound compliance cost. This meant a negative shock to *ao* (the variable representing a percentage change in *AO*),[22] so that the input requirements for producing a given level of output were uniformly increased. The shock used was:

$$ao(milk, USA) = -5$$

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 part of the year. Furthermore, the EU has stringent standards in place to protect surface and ground waters against nitrate contamination from agricultural sources. There was 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 maximum annual residual (MAR) of nitrogen allowed would reduce the number of dairy livestock in the EU by 7.8 per cent.[23] Experiment 2 used this result, again halving the magnitude. It was assumed that a 3.9 per cent reduction in dairy livestock would reduce milk output by 3.9 per cent. In the model, this was represented by a negative shock to quantity of output, *QO*. This was carried out using variable *qo*, representing a percentage change to *QO*.[24] The shock used was:

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[22] The relevant equations that are affected by a shock to the variable *AO*, and later *QO*, are equations (35) and (36) in Table 2.11, Hertel and Tsigas (1997, p. 42). The notation used in the equation can be found in Hertel (1997, pp. 371–96).

[23] The Nitrate Directive impacts not only on dairy production, but on all livestock production and cropping. To achieve the nitrogen MAR, numbers of all livestock would decrease (the extent depending on the livestock type). This would 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 would in turn affect other crops, grain, and other processed foods. This study restricted its investigation to the impact of environmental regulations on only the dairy sector of each of the four regions.

[24] In the standard GTAP closure, the technical change variables are exogenous. When a change is made to one of these variables it may affect output, prices, etc. In this instance we want to make a change to milk output in the EU, i.e. directly shock the variable *QO(milk, EU)*. In order to do this, *QO(milk, EU)* must be made exogenous and the output-augmenting technical change variable *AO(milk, EU)* must be made endogenous. The solution will give the equivalent *ao* shock that would result in a reduction in milk output of 3.9 per cent.

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

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 the United States 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 NZ than for either the United States or the EU. Since there are no available estimates for compliance costs for the Australian milk production sector, these have been approximated by the total compliance cost estimates for the NZ milk sector. The upper bound of 3.2 per cent of total cost was used as an estimate of compliance costs for Australia. The shock used was a negative, output-augmenting technical change shock to Australia's milk production sector of:

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

The shocks to the NZ milk-producing sector in the second experiment were the same as those used in experiment 1.

Finally, a sensitivity analysis was carried out for experiment 2, by halving the size of the shocks to the other three regions. Interest was primarily in the direction (more than the magnitude) of any changes taking place within the NZ 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 was to verify the direction of any changes taking place within the NZ dairy sector.

4.3 Results

Of interest are the impacts on NZ of the different scenarios presented in these two experiments. For this reason, results for NZ are the focus. Experiment 1 was the situation in which only NZ had real costs imposed on its dairy sector as a consequence of environmental standards imposed to improve surface and groundwater quality. As a result, the model predicted a fall in NZ's volume of milk output and processed dairy products by 3.3 per cent and 4.6 per cent, respectively (see table 3). The negative productivity shock to the milk production sector caused a contraction of this sector relative to other sectors. More capital and unskilled labour was now required for every litre of milk produced. The demand for unskilled labour in the milk sector rose by 6 per cent despite the 3.3 per cent drop in the volume of milk produced. To meet that rise in demand for unskilled labour, there was a small shift of unskilled labour (less than 0.5 per cent) from most other production sectors. NZ's supply price of milk and processed dairy products

Table 3 Comparison of the percentage change[a] 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

Note: [a] Actual change for the welfare measure.

rose by 3.2 per cent and 1.6 per cent respectively (table 3). However, price changes in NZ had no impact on the world price index for milk, and only a minimal impact on the global dairy export price index. Consequently, NZ experienced a reduction in the overall quantity of dairy exports to all destinations of between 4.7 and 6.3 per cent (see table 4). Thus the total value of NZ's dairy exports fell by more than 4 per cent (table 3) and NZ suffered a decline in welfare. However, this fall in welfare could have been negated by the positive welfare effect resulting from improved surface water and groundwater quality, which is not included in this welfare measure.

Experiment 2 was the scenario where each of the four principal dairy exporting regions had water quality standards imposed, raising real costs to the dairy sector of each region. The EU had 45 per cent of the world dairy export market. Therefore it was the shock to reduce total milk output in the EU by 3.9 per cent, which had the greatest impact on all four principal dairy exporting regions. With milk output down by nearly 4 per cent, the volume of dairy products produced in the EU decreased by 6 per cent. Domestic demand for dairy products fell by only 3 per cent, so clearly the exportable surplus of dairy products from the EU was reduced. Also dairy products produced in the EU experienced a price rise of 16.6 per cent. The other dairy exporters also experienced an increase in the price (fob) of their dairy exports, but this was by only 1.6 to 3.2 per cent. Therefore the world price index for total supply of dairy products increased by almost 9 per cent (see table 3). Also the global dairy export price index rose by 13 per cent (table 3). The EU experienced a price increase for dairy exports at least five times larger than the percentage increases experienced by its 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 per cent, and by as much as 38.5 per cent to North-east Asia.

Table 4 Experiment 1: effect on the quantity of export sales of dairy products from the principal dairy exporters (per cent change) — *qxs*

Destination:	NZ	Australia	EU	USA	Canada	NE Asia	SE Asia	Central America	Russia	ROW
Exporter:										
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 Experiment 2: effect on the quantity of export sales of dairy products from the principal dairy exporters (per cent change) — *qxs*

Destination:	NZ	Australia	EU	USA	Canada	NE Asia	SE Asia	Central America	Russia	ROW
Exporter:										
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

New Zealand, with a much smaller supply price rise for both milk and dairy products than those for the world market, was able to expand production and increase exports. The volume of milk and processed dairy product output rose by 8 per cent and 12 per cent respectively (table 3). This, combined with a reduction in productivity in NZ's milk sector, meant a shift of resources into these two sectors (primarily from other crops and sheep production). The model predicted a substantial increase in the quantity of processed dairy exports from NZ to all export destinations from a 2.8 per cent increase to North-east Asia, through to a 57.5 per cent increase to the EU (table 5). Consequently the total value of NZ dairy exports increased by 19 per cent (table 3). NZ GDP and household income rose, and there was a positive effect on welfare (table 3), quite apart from the improvement in welfare brought about by improved water quality. The sensitivity analysis confirmed the direction of the changes as a result of the shocks imposed in experiment 2.

5. Conclusion

It was found that environmental control costs for the NZ milk sector resulting from water quality regulations are a relatively small proportion of the milk sector's total production costs, at 2.1 to 3.2 per cent, which is in line with Dean's observations (1992).

The examination of the trade impact of these environmental control costs was examined under two separate scenarios. In the case where NZ unilaterally imposed these costs on its milk production sector, the CGE model predicted that the result would be a reduction in the volume of NZ's dairy exports to all destinations, and a decline in the total value of dairy exports. This indicated a potential loss of competitiveness for NZ in the global dairy market, and a loss in welfare. In the second scenario, ECC were imposed on dairy farmers in all four principal dairy-exporting regions. With the predicted reduction in the quantity of dairy products produced and exported from the EU, the price of the EU's dairy products increased relative to the other main dairy exporters. This caused the EU to lose global market share. Consequently, there was a gain in competitiveness for NZ in the global dairy market, and an increase in welfare.

The results show that trade impacts could be significant. These results, however, are dependent in particular on the way the ECC are distributed between farmers and the rest of society in each of the four regions. With substantial 'aid' in the form of subsidies, grants, tax write-offs, etc. in the other regions (none of which exist in NZ), the actual situation could be closer to experiment 1 than experiment 2. Without those 'aids', the situation will be in the direction of experiment 2, showing the results of NZ'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 in the model. Furthermore, outcomes are impeded by the fact that the GTAP model does not specifically incorporate either environmental policy or environmental externalities, nor does it measure the benefits to society of improved water quality. Work needs to be done to include these in CGE models like GTAP in order to fully analyse the effect of environmental policy.

The other main difficulty was the lack of comparable data on the impact 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 United States (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 were not available, a number of assumptions and approximations had to be made. Clearly, further research into compliance costs for water quality regulations is required in the other three principal dairy exporting regions.

Regulation of 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 imposed in the major dairy-exporting regions.

Also, 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.

Appendix

Table A1 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 and other processed food
Central America	Manufacturing and services
ROW	Capital goods commodities

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