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

A thesis presented in partial fulfilment of the requirements

for the degree

of Master of Applied Economics

at Massey University

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1999

Abstract

This thesis 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.

In response to the Resource Management Act 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. An applied general equilibrium approach (GTAP) is used to analyse the possible impacts 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 costs of such regulations.

The cost to the dairy farmer of implementing a land-based effluent disposal system in order to meet water quality regulations is estimated at 2 to 3.2% of total farm costs. In the first scenario, given this increase in costs, the model predicts a loss in international competitiveness for the New Zealand dairy exporting sector. Under the second scenario, the global dairy export price index is predicted to rise by considerably more than the increase in the supply price of New Zealand's processed dairy products. This will mean a realignment of international trading patterns and an expansion of the New Zealand dairy exporting sector, thereby increasing its global market share.

Acknowledgements

To those who have laboured with me on this thesis I am deeply indebted. My thanks go firstly to Anton Meister who has good-naturedly tolerated my endless questions, and has provided valuable and much appreciated comments. To my second supervisor Allan Rae for explaining to me the mysteries of GTAP. Thanks also to Ross for the hours of proof reading and for the belief that yes, a mathematical mind can learn to articulate. To Leanne Smith and Julia Fisher for their encouragement, support, and humour - I would have lost my sanity without them. I wish also to thank Natalie Moess for her help with the typing, but more importantly for her friendship and her listening ear. Finally, and most importantly to Ross, Matt and David for their patience, support and understanding.

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Introduction

1.1 Background

It was not until the late 1960s and early 1970s that the level of degradation of the natural environment became a focus of concern in developed countries. Initially attention was directed at the high level of pollution from heavy industry. However, as knowledge regarding the assimilative capacity of the environment increased, the issues broadened beyond industry, to include agriculture and forestry and the effects that these sectors have on water, soil and air quality, as well as endangered species and habitats. Concern too, has moved beyond national boundaries to the large scale problem of transborder and global pollution, such as occurs in the form of acid rain, toxic wastes, nuclear contamination, ozone layer depletion, and greenhouse gas emissions (Anderson and Blackhurst 1992; Uimonen and Whalley 1997).

Whereas previously it was the industrial sector that came under attack, now the primary and service sectors are coming under increasing scrutiny by environmentalists. For this reason "countries are exploring ways to reform their agricultural policies in order to make them less environmentally damaging" (Williamson 1993, 127).

Over several decades a large number of regulations and standards have been put in place in order to try and protect the environment. Environmental regulations 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 indicate 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). This result follows as a normal consequence of the differing endowment of environmental assimilative capacity and demand for environmental quality in different countries. However, some concerns about this development have been raised by various groups of people. On the one hand are the environmental groups who see this development as leading to pollution havens, with polluting industries moving to countries with weaker environmental regulations. On the other hand are the advocates of free trade, who see forty years of multilateral negotiations and associated changes to domestic trade law being threatened by a new form of protectionism under the guise of environmental concern.

New Zealand is a small economy for which trade plays a vital role, with export earnings contributing 31% of New Zealand's GDP (Statistics New Zealand 1998). Furthermore, New Zealand is both proud of, and dependent on the quality of her environment for the production of clean and green products, and for the growing level of international tourism. Therefore protecting the environment through regulations and standards is essential for New Zealand. This makes the question of cost and possible trade impacts of these environmental regulations relevant to the economy and for the purposes of this study, the dairy sector in particular.

1.2 The Importance of Agriculture in the New Zealand Economy

New Zealand's landscape is hilly and mountainous. Some 27% of the land area is forested in either indigenous or exotic forest. Pasture and arable land make up 51% of the land area and most is privately owned. Traditionally farming has been in sheep and cattle with produce for home consumption and for export. Cereal crops are grown primarily for the home market. This was also the case for horticultural produce, but since the 1970s the horticultural sector has become an important export earner (Statistics New Zealand 1998).

Agriculture is more important to the economic prosperity of New Zealand than it is in most other developed countries, with its produce making up more than half of the country's merchandise exports. New Zealand is the world's largest exporter of sheepmeat, the second largest dairy exporter and a significant exporter of beef. In horticulture, New Zealand has an important share of the kiwifruit and apples global market (Hewison 1995). Sheep and beef cattle numbers have been declining but dairy cow numbers increased 2.1% in the year ended 30 June 1996 and again 1.6% the following year. This, and favourable weather conditions resulted in the highest level of milk production being recorded for the year ended May 1997, an outcome which may be surpassed in the current season ending May 2000.

New Zealand farmers, unlike most in the developed world, receive no subsidies except for spending on inspection, quarantine, research, pest control, and some assistance to bring about sustainable land management practices. This was not always the case, with government assistance to agriculture coming in the form of price supports, export subsidies, tax concessions, capital and input subsidies, low interest loans and free advisory services to farmers. Assistance to farmers reached a peak in 1984, but thereafter was dramatically reduced in what was seen as an essential part of the country's economic reforms. In terms of total transfers per full-time farmer equivalent, New Zealand farmers were the least assisted of all the OECD countries in 1995 (Statistics New Zealand 1998). Producer subsidy equivalents (PSEs)[1] to the New Zealand agricultural sector have remained steady around the 3% level since 1992 and for milk production it is only 1.6% (MAF 1998)[2]. In contrast, the PSE for milk in the EU is above 50%. With such a low level of assistance New Zealand farmers are totally exposed to world market forces. Market adjustments have occurred with changes in land use toward forestry and in some areas pastoral farming (the most subsidised agricultural activity) has given way to horticulture. "Farmers and exporters in New Zealand have had to explore and develop new non-traditional markets. This they have done with remarkable success" (Statistics New Zealand 1998).

[1] The producer subsidy equivalent (PSE) is a measure used to determine the level of government assistance to production. It measures government subsidies and the extent to which domestic prices are above world prices as a result of government intervention in markets and trade. The PSE is expressed as a percentage of total production and as such is a clear indicator of the level of government intervention in the agricultural sector (MAF 1998).

Within agriculture, the dairy sector has changed rapidly over the last decade not only in size and intensity, but also to a lesser extent, in location. The volume of milk processed has increased by 54% in the last decade. While the volume of milk output has been steadily increasing, the number of dairy herds has shown a gradual decline. The trend has been for the average herd size to increase. In the 1997/98 year 18.6% of herds carried at least three hundred cows, whereas only 6.5% carried this number in 1990/91 and only 1.5% of herds were this size in 1980/81. The total cow population increased 5.2% in the 1997/98 year, as did effective hectares, both increases being consistent with the trends that have occurred since 1981/82. The other notable change has been the opening up of traditionally non-dairy areas like Otago, Southland, Canterbury and Hawkes Bay, to dairy farming. Some 14% of dairy farms are now located in the South Island where farms are larger, both in terms of land area and herd size. Genetic gain and improvements in farm management have led to increased productivity per cow over the last decades (Livestock Improvement 1998). One quarter of gross earnings from agricultural production in 1995 was from dairy products.

With the steady increase in milk production over the years, has come an increase in dairy exports, which now constitute 20% of total merchandise trade receipts for New Zealand. Every category of processed dairy produce has experienced an increase in the volume exported since the 1992/93 year, with the quantity of both skimmilk powder and cheese doubling from 1992/93 to 1996/97, and the overall volume of dairy exports increasing by 55% in the same time period. Trade destinations for New Zealand dairy products have also changed in recent years. For the 1996/97 year, Malaysia was the biggest single importer of New Zealand skim and wholemilk powder, while 22% of New Zealand cheese exports went to Japan. Russia is now the largest market for New Zealand butter, Mexico for anhydrous milkfat/ghee and the United States imports 45% of our export casein (New Zealand Dairy Board 1998a). Expansion, in both milk production and dairy exports have been encouraged by the GATT Uruguay Round Agriculture Agreement. The Agreement imposes progressive reductions on the subsidies that other countries can give to agricultural

[2] The 1998 provisional figure for the New Zealand PSE for milk production is 0% (OECD 1999).

production and exports and it increases access opportunities for New Zealand exports in overseas markets. The implications for New Zealand are very favourable as "small changes in the subsidy regimes in the European Union and the United States can have large impacts on world prices for the commodities exported by New Zealand" (Rae and Nixon 1994).

1.3 The New Zealand Dairy Sector and Environmental Concerns

Although New Zealand dairy export prospects are good, what is of concern, is the negative impact intensive dairying can have on the environment.

1.3.1 The environmental issue associated with dairy farming

The key environmental issue associated with dairy farming is that of water quality, which is compromised by excess levels of nitrate. Nitrogen from livestock manure is converted to nitrate once on the ground[3]. Nitrate is absorbed by plants and is necessary for their growth. However, with increasing herd sizes and stocking densities, growing pasture cannot always absorb the increasing quantities of nitrate that are delivered to the soil. Excess nitrate eventually leaches into groundwater or runs off into surface water. This contributes to excess nutrient levels in water and is known as eutrophication. Eutrophication in surface water gives rise to algal blooms, which take oxygen from the water and destroy aquatic life (Leuck *et al* 1995).

The other concern is that nitrate may also be harmful to livestock as well as human health. High levels of nitrate affect the metabolism of livestock, reducing their feeding efficiency (Garner 1958)[4]. High nitrate levels may also cause a condition in humans called methemoglobinemia which reduces the capacity of the blood to carry oxygen. This is especially a problem in newly-born infants, where the condition is often referred to as 'blue baby' syndrome. A study by Walton (1951)[4] found no incidence of methemoglobinemia where drinking water had less than 10 parts per million (ppm) of nitrate. Just over 2% of cases of methemoglobinemia occurred when drinking water contained 10-20 ppm of nitrate and this increased to 17% for 20-40 ppm of nitrate. This meant that over 80% of occurrences of 'blue baby'

[3] Nitrate in the soil also comes from nitrogen fertiliser in the same way. It also comes via acid rainfall, from automobile exhausts, electrical storms, and industrial pollution.
[4] Cited in Leuck *et al* 1995.

syndrome were where drinking water contained in excess of 40 ppm of nitrate. It was these findings that prompted the World Health Organisation and the United States Environmental Protection Agency to recommend that the maximum level of nitrate in drinking water be 50 ppm. "Nitrosamines may also arise as products from consumption of nitrates. High levels in water and diet have been linked to some type of cancers" (Young and McNeill 1999,64). The Ministry of Health for New Zealand has set a maximum allowable nitrate limit in drinking water of $50g/m^3$, which is equivalent to $11.3g/m^3$ of nitrate-nitrogen[5] (Taylor and Smith 1997).

There are several contributing factors that influence the amount of nitrogen that is leached into groundwater as nitrate. These factors include soil structure, the amount of rainfall, and the depth of the water table. Leaching may take several decades or it may occur rapidly where the aquifer is close to the surface, soils are sandy, human activity is significant, and the refill rate from rainfall or irrigation is high (Leuck *et al* 1995; Taylor and Smith 1997). Nitrate contamination tends to be worst in areas of intensive livestock production.

1.3.2 Water quality regulations

In New Zealand all the resource issues of water, soil, air and nature conservation and management come under a single piece of legislation, the Resource Management Act, 1991 (RMA 1991). The RMA 1991 controls all discharges into water, by setting minimum water quality standards. These prohibit, after reasonable mixing,:

- conspicuous oil or grease films, scums, foams, or floatable or suspended materials
- any conspicuous change in the colour or visual clarity
- any emission of objectionable odour
- the rendering of fresh water unsuitable for consumption by farm animals
- any significant adverse effects on aquatic life.[6]

The RMA 1991 provides Regional Councils some flexibility in how they administer and enforce the Act. The Regional Councils control the activities of resource users with regard to environmental effects, through rules, regulations, voluntary actions,

[5] The nitrogen makes up only a small part of the total nitrate molecule, NO_3.

[6] For details of the relevant sections of the RMA 1991 see Appendix 1.

and education. Insofar as dairy farmers are concerned, this translates into regulations and rules on effluent disposal and guidelines for fertiliser applications.

1.4 Objectives of the Research

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 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.

1.5 Limitations of the Research

A case study approach has been taken for this research. The investigation is limited to the effect that environmental regulations have on water quality with respect to the New Zealand dairy sector only. The impact of water quality regulations will fall not only on dairy production, but also on other livestock production as well as cropping (through the use of nitrogen fertiliser)[7]. Clearly changes would have to take place in these other sectors as well, in order to comply with the water quality regulations. These changes are likely to increase production costs, which will impact on the volume of output in these sectors (quite apart from the indirect effects that arise as a result of changes in the dairy sector). This research assumes enforcement of the water quality regulations in the dairy sector while ignoring direct impacts the same regulations have on other livestock, cropping and, indirectly, the meats, wool, and other processed foods sectors. It is acknowledged that limiting the direct impacts of

[7] This will certainly be the case for the Nitrate Directive of the EU.

water quality regulations to the dairy sector only, in each country in this study, is a limitation in the analysis of competitiveness effects.

1.6 Thesis Outline

This thesis is organised as follows. Chapter Two presents a brief survey of the literature. Chapter Three provides a description of the on-farm changes made in New Zealand in order to comply with the water quality regulations and also provides an estimate of the cost of these changes. The fourth chapter outlines the relevant regulations, compliance cost estimates, and government assistance to the dairy sectors of the other three principal dairy exporters. Chapter Five provides a detailed explanation of the model used to investigate the trade impacts of the increased cost of production in the New Zealand dairy sector. Chapter Six discusses the results and the final chapter concludes the thesis.

Chapter Two

Review of the Literature

2.1 Introduction

The latter half of this century has witnessed a profound change in the world economy. Since 1950 the world population has risen from two and a half billion to six billion. The average income is two-and-a-half times what it was, and there has been a six-fold increase in global GDP. Advances in communication and information technologies, increased trade liberalisation, and reduced barriers to foreign investment have seen an integration of the world economy and a vast increase in the amount of economic activity (Nordstrőm and Vaughan 1999).

This escalation of economic activity has resulted in the degradation of the natural environment, including air and water pollution, depletion of the ozone layer, global warming, deforestation, a loss in bio-diversity, and over-fishing, to name but a few of the impacts. By the late 1960s and early 1970s the level of environmental degradation had became a focus of concern in developed countries. Initially attention was directed at pollution from heavy industry, which was thought to occur within localised areas, or at worst across neighbouring countries as in the case of acid rain between the United States and Canada, and between Germany, Poland, and Sweden. However public concern intensified in the late 1980s with the realisation that environmental problems were embedded in a global ecosystem and were the direct result of ever-increasing human activity (Anderson and Blackhurst 1992; Uimonen and Whalley 1997). Stratospheric ozone depletion caused by chlorofluorocarbons and halons was linked to industrial activity. Global warming was also linked to industry and transportation through carbon dioxide emissions from the use of carbon-based energy products such as coal and oil. The contribution that deforestation[8] made to global warming also began to be understood. Some 20% of

[8] Deforestation reduces the amount of CO_2 that can be naturally absorbed.

the world's tropical forests had been cleared between 1960 and 1990 (Source: World Resources 1998-99).

Anderson and Blackhurst (1992) suggest three main reasons for the observed increase in environmental degradation. Firstly, the mounting pressure faced by the world's natural resources in the last few decades. World population numbers have escalated and globalisation has led to an acceleration of economic growth, with the annual production of goods and services nearly doubling since 1970. These increases escalate the demand for energy sources[9], other primary products, and for basic human needs like clean air and water[10], filtered sunlight, natural foods and medicines. Secondly, markets have not developed for most of nature's services because of the absence of well-defined property rights or because the cost of enforcing those rights is just too high. Resources are vulnerable to degradation and this is especially so where the 'global commons' is concerned. Without clearly defined or enforced property rights economic expansion persists and pollution continues at an increasing rate. Thirdly, environmental degradation is worsening due to the failure to address the issues, both by poorer economies at the national level, and by all nations at the international level. The seriousness of these global environmental issues make apparent the need for some form of global management, which suggests some regulation or intervention in the global economy (Uimonen and Whalley 1997).

The difficulty in finding solutions to these problems is further compounded by trade liberalisation, which has increased markedly in the last two decades. This has brought increasing tension between those who advocate freer trade and those who advocate environmental protection. The globalisation of environmental concerns has escalated this tension insofar as many of the issues can no longer be solved at a national level. There seem to be two key problems in the relationship between trade and environmental policies. One is "the extent to which trade policies might be used,

[9] Global energy use has increased nearly 70% since 1971, is projected to increase at more than 2% annually over the next 15 years, which will raise greenhouse gas emissions by 50% over current levels unless there is a move away from today's reliance on fossil fuel (Source: World Resources 1998-99).
[10] Global water consumption is rising quickly, and the availability of water is likely to become one of the most pressing issues of the 21st century. One third of the world's population lives in countries already experiencing moderate to high water shortages (Source: World Resources 1998-99).

as first-best or second-best measures for environmental reasons. This, in turn, raises questions about the extent to which trade restrictions may be useful in dealing with cross-border environmental problems as well as 'global commons' resources. The second set of issues concerns the 'competitiveness' effects of environmental standards differentials between countries" (Uimonen and Whalley 1997, 37). Do lower environmental standards give a country an unfair trade advantage, and, will environmental regulations bring in a new form of protectionism? In order to address these questions, this chapter will investigate the linkages between environmental regulations and trade, focusing on this second set of issues.

2.2 Environmental Regulations and Loss of Competitiveness

A range of different factor endowments can lead to a country having a comparative advantage on an international scale. Endowments could include land, labour, capital, technological knowledge, agricultural policies and environmental quality and policies (OECD 1994). A country with a rich environmental endowment and high assimilative capacity[11] may have less concern for its environment, since less concern is required. In support of this, Anderson (1998, 13) says that "severity of environmental regulations tend to be positively correlated with population density, with degree of urbanisation and with the level of per capita income." Increases, both in standard of living and in concern for global environmental issues, will put pressure on governments to impose higher environmental standards but "if environmental regulations overcome environmental externalities optimally, then they can be thought of as just another determinant of comparative advantage" (Anderson 1998, 12).

Others advocate a harmonising of environmental standards. OECD (1994) suggests the need for international co-operation to come up with acceptable guidelines to avoid large discrepancies in environmental priorities and practices that could lead to trade tensions. Principle 11 of the Rio Declaration asserts that "states shall enact effective environmental legislation" while recognising that "standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries". Anderson (1998), Anderson and Blackhurst (1992) and Ervin and Fox (1998) emphasise that environmental effects

[11] 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).

are site specific and that different environments have different assimilative capacities. An appropriate standard then for one country might be quite excessive for another. Anderson (1998) highlights this in view of countries like Australia and New Zealand which are relatively abundant in natural resources and low in population density, not requiring the same level of standard as places like Western Europe. Bhagwati (1996) suggests that nations may well agree with the polluter-pays principle but could settle on very different amounts depending on the value placed on the external effect and the level of pollutants a society is willing to tolerate. He is adamant that a move toward identical pollution tax rates or environmental standards is the wrong move. His argument is that even if two economies did "have the same utility function in the aggregate, the specific compositions of environmental preferences may be very different" (Bhagwati 1996,16). Therefore if the areas of serious concern are different, (due to physical differences and people's needs), then the two different countries will want to concentrate their resources into those different areas rather than be restricted by identical taxes or standards. "There may well be increasing convergence in environmental objectives over time, as incomes, tastes and pollution assimilation capacities become more similar internationally. But this is no argument for enforced uniformity" (Low and Yeats 1992, 89).

Therefore, if different environmental regulations and standards are appropriate for different countries, will these different standards affect international competitiveness? Ratnayake (1996) says that there appear to be two conflicting views. The first is that a country with stringent environmental regulations imposes significant costs on its own domestic industry and therefore reduces its international competitiveness. Furthermore, low environmental standards serve as a subsidy to their producers, and countries with low standards can become 'pollution havens' for foreign investment in pollution-intensive industry. "These claims have led to proposals to combat the competitive effects of such 'ecodumping' by imposing import charges reflecting the difference in the unit costs of environmental protection. Ecodumping charges were proposed in the US in the International Pollution Deterrence Act of 1991. Under this proposal, any goods, in countries with environmental standards determined to be below those of the United States would be subject to countervailing duties when imported into the United States" (Uimonen and

Whalley 1997, 31). The other view is that by stimulating innovation and productivity improvements, strict environmental regulations may actually enhance competitiveness (Porter 1991; Porter and van der Linde 1995).

2.3 Evidence of Environmental Regulations and Loss of Competitiveness

A large number of studies have been conducted in an attempt to quantify the impact of environmental regulations on industry price and output and hence on loss of competitiveness. Robison (1988), Tobey (1990, 1993), Low and Yeats (1992), Birdsall and Wheeler (1992), Wheeler and Mody (1992), Schmitz, Boggess, and Terfertiller (1995), Leuck *et al* (1995), Song (1996), Ratnayake (1996), Ferrantino (1997), van Beers and van den Bergh (1997), Boggess, Johns and Meline (1997), Xu (1998), and Frandsen and Jacobsen (1999) are some such studies. Some of these, and others, have also investigated the validity of the 'pollution haven' theory.

One of the earlier empirical studies was done by Robison (1988) using an ex-post partial equilibrium framework to measure the impact of marginal changes in industrial pollution abatement costs on the US balance of trade. The framework ignored all offsetting general equilibrium effects such as changes in exchange rates, and the assumption was made that full costs would be passed on. The evidence suggested that marginal changes in industrial pollution abatement costs reduced the US balance of trade for most industries. "In addition, empirical support is found for the proposition that industrial pollution abatement is inducing changes in the US comparative advantage such that the abatement content of imported of imported goods is rising relative to that of exported goods" (Robison 1988, 196).

"The premise that trade suffers from the imposition of environmental policy has a strong element of *a priori* plausibility but, surprisingly, has little empirical support" (Tobey 1990, 191). Tobey (1990, 1993) analyses the impact of environmental regulations on comparative advantage patterns using a multi-country econometric analysis employing the "Heckscher-Ohlin-Vanek" (HOV) model[12]. He regresses the net exports of five different pollution-intensive industries for twenty-three countries. For his environment variable Tobey uses stringency of regulations, varying from 1 to

[12] Used also by Song (1996) in his empirical investigation of Asia and the Pacific's changing global comparative advantage.

7, and these act as the proxy for the stock of the environment. The assumption made is that a country with more stringent regulations has a lower environment stock. His study does not produce evidence to support either a negative impact of environmental regulations on trade flows nor the 'industrial-flight' hypothesis which suggests that rigorous pollution control measures encourage polluting industries to move to an alternative location where environmental policies are less stringent.

Van Beers and van den Bergh (1997) suggest that the disadvantage of Tobey's use of the HOV model is that it is based on multilateral trade flows. Since multilateral trade is an aggregate of bilateral trade flows, it may cancel out the effect of differences in the stringency of environmental regulations on trade flows. For this reason they use a trade flow equation which takes into account bilateral trade flows. The hypothesis tested is that countries with relatively stringent environmental regulations experience a reduction in exports and an increase in imports. Previous empirical studies concentrating on the impact of strict anti-pollution standards on exports found insufficient evidence to show a significant negative influence. Van Beers and van den Bergh (1997) argue that the indicators used to reflect environmental policy stringency could be the reason for the inconclusive results. They use two different measures of environmental policy stringency, which are discussed and evaluated against the Polluter Pays Principle. One is closely connected to the Polluter Pays Principle. These are used in the trade flow equation to analyse a cross-country data set of OECD countries for 1992. With the environmental policy measure closely connected to the Polluter Pays Principle, the impact of stricter regulations on export flows is statistically significant and negative. "Eliminating the dominant influence of resources on the competitiveness pattern by using non-resource based bilateral trade flows as the independent variable, shows a significant negative effect on exports of 'dirty' non-resource based commodities. Both results are consistent with recent theoretical work which emphasises that strict environmental policies do have a strong impact in the case of non-resource based industries" (van Beers and van den Bergh 1997, 43), but for resource based industries the main determinant of competitiveness is ownership of that resource. Interestingly, the hypothesis that stringent environmental regulations exert a positive effect on imports is rejected. 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.

Ferrantino's (1997) study looks at pollution abatement costs in the manufacturing sector both in the US and in developing countries. Using data from the two decades ending in 1992, his aim was to look at the effects on the revealed comparative advantage (RCA) of the US. Some industries within the US manufacturing sector, notably those producing paper and paperboard, chemicals, iron and steel, petroleum and coal products as well as non-ferrous metals, have significantly more pollution and hence higher abatement costs. For these industries, abatement operating costs and capital expenditures represent 2-3% of their total costs. Costs to other industries are less than this. This suggests that without the abatement costs in these pollution-intensive industries, the US could lower its product prices relative to foreign prices by two to three percent at most. Ferrantino suggests this to be a relatively small competitive effect. Furthermore, the figures indicate that in the twenty-year period those 'dirty' industries seem to have had a trade performance that followed closely the trade performance of all traded commodities of the US. "This suggests that the competitive performance of these industries is determined to a far greater extent by macroeconomic conditions, such as exchange rates and the relative timing of US and foreign business cycles, than by environmental policy. If environmental policy were the primary driving factor, it would have induced steady deterioration in the trade performance of these industries" (Ferrantino 1997, 53). Also if there were to be any effect on competitiveness as a direct result of costs for environmental regulatory compliance then this should be noticeable between the trade of highly regulated countries, in this case the US, and less regulated developing countries. Ferrantino's study did not bear this out. Developing countries did make competitive gains in the 'environmentally sensitive' industries, but clearly not at the expense of US trade (Ferrantino 1997). For this reason he suggests that it might be of more interest to compare the competitiveness (resulting from environmental regulations) of the US with other developed countries, particularly those which are resource-intensive.

One of the few empirical studies on this topic involving New Zealand data is that done by Ratnayake (1996). He compares data for the years 1980, 1985 and 1993, testing the "hypothesis that environmental stringency leads to loss of international competitiveness in manufactured exports" (Ratnayake 1996, 21). He does this in three ways, each time comparing New Zealand with three different country groups, OECD, ASEAN and the developing countries (DCs). When analysing "the international competitiveness of 109 industries in terms of revealed comparative advantage (RCA) of New Zealand's trade" (Ratnayake 1996, 21) with the other country groups, the evidence revealed no loss of comparative advantage to New Zealand in environmentally sensitive goods.

Ratnayake also used two econometric methods to test his hypothesis. In the first he represented environmental stringency using a dummy variable. In all the equations this variable was not significant, leading him to the conclusion that "environmental stringency is not a major determinant of New Zealand's international competitiveness in manufactured exports to any destination" (Ratnayake 1996, 19). The second method was a variable addition test used to test the hypothesis that environmental stringency has no effect on trade patterns. "The Chi-square and F tests indicate again that environmental variable is not an important determinant of New Zealand's international competitiveness in exports to ASEAN, DCs and the world as a whole. However, both tests are marginally significant under OECD" (Ratnayake 1996, 19). Thus Ratnayake finds no compelling evidence to lead him to conclude that environmental standards do in fact lead to a loss of competitiveness. Likewise Xu (1998) finds no evidence that developing countries have gained a comparative advantage in polluting industries over the period of his investigation from 1965 to 1995.

2.4 Relocation of Industry to 'Pollution Havens'

With the steady increase in both the number and rigour of environmental standards in developed countries, the concern has been that in an environment of open trade and investment, 'dirty' industries will "relocate to a jurisdiction with lower standards" (Ballenger and Krissoff 1996, 61). "In addition, less developed countries (LDCs) may purposely undervalue the environment in order to attract new investment (the pollution haven hypothesis). Both phenomena could lead to non-optimal pollution in LDCs" (Dean 1992, 19)[13].

[13] See also Birdsall and Wheeler (1992)

Low and Yeats (1992) observe that for some developing countries, polluting industries make up an increasing share of their exports, while for developed countries this share is decreasing[14]. But it would be a mistake to conclude from this that 'dirty' industries are migrating as a consequence of differing environmental standards. An alternative explanation may be that growth in developing countries is often associated with a shift out of agriculture into industry. In contrast, growth in developed countries is often linked with a shift out of industry into services (Birdsall and Wheeler 1992). Walter (1982)[15] examines trends in foreign direct investment by firms from Japan, Western Europe and the US during the period 1970 to 1978. He acknowledges that a large amount of production in pollution-intensive industries is occurring offshore[16], but these moves are unlikely to be adequately explained by differing environmental policies. Wheeler and Mody (1992), Low and Yeats (1992), and Leonard (1988) support this view[17]. "Leonard sees no evidence of large-scale industrial flight as a response to US environmental regulations... Other factors, such as the level of training of labour, infrastructure and stability were much more important in location decisions" (Dean 1992, 20).

Even where allowable practices differ substantially across countries, many multinational firms have corporate policies that mandate 'world class' levels of environmental protection in their facilities, irrespective of their location. For such companies, locational decisions are insensitive to national environmental policies" (Gruenspecht 1996, 26). Birdsall and Wheeler (1992) suggest that it may be too costly for multinationals to implement different practices and processes in different locations. Since costs of clean technology and industrial processes are small compared to total costs[18], it may be more cost effective to use the same processes regardless of lower environmental standards where some branches of the corporation are situated. Also shareholder pressure is likely to ensure that multinational companies use clean technology so as not to increase total world pollution. Jaffe et

[14] Lucas, Wheeler and Hettige (1992) note the same, but in terms of total manufacturing emissions relative to GDP rather than export share of the polluting industry.
[15] Cited in Dean (1992, 19).
[16] E.g., Japan's sintering of iron ore and also smelting of copper in the Philippines rather than in Japan (Ofreneo 1993).
[17] Cited in Dean (1992, 20).
[18] Less than 1% for industrial firms in the United States (Low 1991).

al. (1995) speak of multinational's reluctance to build 'less-than-state-of-the-art plants' in foreign countries for similar reasons.

Birdsall and Wheeler (1992) look at Chile as an example of a country open to trade and foreign investment, with limited or no controls on industrial emissions, and ask the question, is Chile a 'pollution haven'? The evidence used on the behaviour of industrial firms in regard to pollution was anecdotal. It seemed that Chilean exporting firms in some cases accepted higher costs to reduce emissions in order to guarantee that the exported product meet foreign standards. "Openness to foreign investment and the absence of barriers to technology imports encourage multinational companies to invest in Chile, and insure that domestic producers will have to compete with them. The fact that cleanliness is embodied in newer equipment and processes, and/or the shareholder effect, push industry toward in effect exceeding local standards...which may lead to importation of industrial country pollution standards" (Birdsall and Wheeler 1992, 163). These standards might be higher than those that are actually efficient, considering Chile's social preferences. They conclude then that openness is cleaner for industry.

Lucas, Wheeler, and Hettige (1992,80) indicate that "restrictive trade policies imposed by developing countries themselves may even have been the main stimulus to toxic industrial migration, rather than regulatory cost differences between the north and south".

2.5 Studies from the Agricultural Sector

Many earlier empirical studies focused on the impact of environmental regulations in pollution-intensive industries. Less has been done to measure the effect on competitiveness 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, suggest this is because environmental provisions in agriculture are more often "vague, subject to interpretation, and lacking in concrete policy prescriptions" (Ballenger and Krissoff 1996, 60). But in the last few years studies have been done in the agricultural sector to examine the economic consequences of environmental regulation. Gardner (1966) stresses the importance of making a distinction between the two steps in the analysis of regulation. These he states are "the cost increases resulting from input/output restrictions or incentive changes, and secondly the incidence of these cost increases on product and factor prices, and hence on the economic well being of individuals" (Gardner 1996, 220). Gardner looks at a number of studies done on the effect of reducing the use of pesticides and inorganic fertilisers in US agriculture. Zilberman et al. (1991) are cited in Gardner (1996) for their investigation of the impact of multi-chemical, multi-crop regulations recommended under the "big green" referendum in California. Their estimate is crop losses to the order of 25 percent. Babcock, Lichtenberg and Zilberman (1992)[19] point out that many pesticides, particularly in fruits, have less effect on quantity and have a greater effect on the quality of the output. Nevertheless this will affect overall returns.

Turning the focus to the incidence of these cost increases on product and factor prices, Gardner (1996) says that it can be difficult to measure the percentage of the cost increase that is borne by the farmer compared with that borne by the consumer. In the domestic market it is found that the increased costs are largely passed on to the consumer due to the relative inelasticity of demand for agricultural output, and the likely increase in demand for agricultural land and labour resulting from reduced chemical inputs. But when exporting, the farmer faces prices determined by the international market. Therefore in the export market, farmers are the ones likely to bear the burden of economic losses induced by environmental regulations.

Since "costs and benefits are specific to each regulation, regulations must be analysed on a case-by-case basis, not as a generic group, to determine how they affect the economy" (Horowitz and Hueth 1995, 1183). Many of the studies done in the agricultural sector have been done at the micro level.

A study by Leuck *et al* (1995) analyses the effect of three different policies for the EU on residual nitrogen, EU agricultural activities, and world markets. The three policies are the Nitrate Directive[20] (1991), the MacSharry proposal for reform of the Common Agricultural Policy (CAP) and a hypothetical, EU-wide, 50% fertiliser tax. A tax is often considered superior to direct controls on fertiliser usage, which can be

[19] Cited in Gardner (1996, 223).
[20] Detailed further in Chapter Four.

difficult to implement on non-point sources of pollution like nitrogen fertiliser. Use is made of the ST86 Trade Policy Model in their analysis. It is a static, partial equilibrium model of world agricultural trade. The ST86 database consists of multiple world-trading regions so that the effect of different actions can be observed on patterns of trade and of world prices. In order to assess environmental policies, the model was modified to include a nitrogen balance component and a nitrogen fertiliser sector. The three policies analysed in this study "are modelled as unilateral EU policy changes, that is, no other country is assumed to change its agricultural policies either in conjunction with or as a result of the EU changes" (Leuck *et al* 1995, 16).

The study concludes that a fertiliser tax would be the most effective in reducing the delivery of nitrogen to the soil. The 50% tax reduces demand for nitrogen fertiliser by about 10%, resulting in a decline in grain production of around 2%. The effects of both the fertiliser tax and the CAP reform are spread throughout the EU. This means that nitrogen use would decrease even in grain-producing regions where nitrate problems do not exist. Furthermore it would not reduce nitrate pollution in areas of intensive livestock production. The Nitrate Directive is better suited for this. Leuck *et al* (1995) estimate that in order to achieve the nitrogen maximum annual residual (MAR) permitted by the Directive, EU livestock numbers must be reduced by as much as 12% for pigs, 10% for poultry and 1% for sheep. Under the Nitrate Directive, the EU could become a net importer of livestock products, export more wheat and coarse grains, and import less corn and oilseeds. World livestock and corn prices would rise. Alternatively, under CAP reform crop and beef production would decline, and wheat and coarse grain exports would fall. Dairy production would remain stable but pork and poultry production and exports would increase. Clearly then the Nitrate Directive would be better than the CAP for reducing livestock production. However, a combination of the Directive and the CAP reform results in a decrease in both livestock and crop production in the EU. In this scenario world livestock prices are up the most, but world crop price rises are less than they would be under just the CAP reform. This is because there is now less demand for animal feed in the EU.

Frandsen and Jacobsen (1999) investigate the economic effect of reducing the use of pesticides in Danish agriculture. They use a standard, neo-classical computable general equilibrium (CGE) model specifically tailored for Denmark. It is used to test the effect of both a complete ban and a partial ban on pesticide use in Danish agriculture. The structure of the model chosen "allows for substitution between herbicides and an aggregate of capital, labour and energy, substitution between fungicides and fertilisers, as well as substitution between insecticides and an aggregate of fertilisers, fungicides and agricultural land. ...The factor-mix in these alternative technologies is determined as the percentage increase in the different input factors per unit of output relative to the traditional technology (using pesticides)" (Frandsen and Jacobsen 1999, 7). In the model the employment of technologies using pesticides is significantly reduced in one instance and completely excluded in the next. This frees up agricultural land, labour, and capital to be employed elsewhere in the economy. Agricultural land is now used in the pesticide-free crop sectors and there is a decline in the returns to land, labour and capital.

The analysis shows pesticides as a vital input factor in crop production and concludes that a total ban on the use of pesticides would dramatically change agricultural production and affect other parts of the Danish economy. The ban on pesticides was not global but specific to Danish agriculture. Therefore the model allowed for Denmark to import agricultural products that had been treated with pesticides. This results in Danish agricultural commodities being replaced by imports which in the model has serious negative impacts on Danish crop production. Lastly the model does not take into account the possibility of consumers being willing to pay a higher price for pesticide-free products.

Komen and Peerlings (1996) also use an applied general equilibrium (AGE) approach in their investigation of the effects of the Dutch energy tax introduced in 1996. The tax of 19.1% on electricity and 27.6% on gas, targets households and small energy users while exempting horticulture under glass and large industrial users. Revenue created by the tax is used to lower the pre-existing, distortionary taxes related to labour income in the Netherlands.

An AGE analysis was chosen since the effect of the tax would be economy-wide. The model used gives a complete description of the Dutch economy. In addition it is detailed in regard to agricultural industries, allows for factor mobility between industries and uses the Armington assumption[21] for modelling trade. Technological changes are not modelled therefore no account is taken of the likelihood of technological change occurring as a result of the high energy prices. Neither is there consideration that other countries may well follow with energy taxes of their own.

The study concludes that the 1996 energy tax results in higher energy prices for small users and reduces energy consumption. Electricity prices were up 14.1% and gas prices were up 17.6% for small users but were down for large users by 4.2% and 7.8% respectively. Economy-wide consumption of electricity reduced by 3.1% and gas consumption by 3.8%. Total CO_2 emissions were down 0.8%, but this is approximate since emission coefficients per energy source, and per industry are not incorporated in this model. There is little effect on agriculture. Since horticulture is exempt from the tax, it benefits from the lower gas price, increasing production by 1% (and gas consumption by the same). The energy-intensive fertiliser industry also expands, using 7% more gas and raising the level of production by 5.1%. The use of tax revenue reducing labour costs, increases employment by 0.07% and improves national welfare. If horticulture had to pay the energy tax then energy consumption for horticulture would decrease; production would fall by 2.3% and income by 4.1%.

Several studies have been done[22] to look at the economic impacts of some or all of the three water quality programmes (WQP) implemented in the late 1980s in the Lake Okeechobee Watershed of Florida. The concentration of dairy farming in the area has resulted in high phosphorus levels in runoff water entering the lake. The first of the WQP was The Dairy Rule, which required dairies to comply with an authorised system for collection and treatment of wastewater and runoff from dairy sheds before being released into state water bodies. The second was The Dairy Buy-Out Programme, which saw sixteen dairies voluntarily cease operations during 1989 to 1992 receiving a one-time payment of $602 per cow. The Okeechobee Works of

[21] This assumption is explained in Chapter Five.
[22] Boggess, Johns and Meline 1997; Schmitz, Boggess and Tefertiller 1995: Boggess, Holt and Smithwick 1991; Mulkey and Clouser 1991.

the District Rule (WOD) was the third of the WQP. It imposed a maximum allowable phosphorus concentration in drainage water at discharge points of agricultural properties. Roughly 40% of the total cost of implementing the WQP, which came to in excess of $51 million from 1987 to 1993, was met by the dairy operators with the remainder paid by Florida state agencies. Implementation of these WQP have resulted in a 26% reduction in dairy cows in the study area. However, overall milk production fell by only 17% as the drop in number of cows was partially offset by a 13% average increase in milk production per cow as a direct result of the new manure management practices. These include the use of confinement barns which improve wastewater management using effluent retention ponds and spray irrigators. Boggess, Johns and Meline (1997, 2691) conclude that "dairies that complied with the WOD spent, on average, $1.14 per hundredweight" of milk, but "this additional cost was more than offset by the 13% increase in mean milk production experienced as a result of the WOD investments. Thus, the losses to the dairy sector in the study region primarily reflected the relocation of dairies to other regions rather than losses in income to remaining dairies. ...Statewide, the WQP resulted in both direct and indirect incentives for dairies to locate in other parts of the state or in other states. Thus, increased milk production in other areas of the state offset most of the decrease observed in the study area. As a result...no change in retail milk prices occurred as a result of the WQP."

These stringent regulatory policies were confined to a particular water catchment area. From a regional point of view there was a shift of this more pollution-intensive industry to areas, albeit still within the state of Florida, with less stringent regulatory policies. Innovation offsets arising in response to the environmental regulations meant no loss of competitiveness for the dairy farms that remained. It is interesting to note that in spite of this, farmers ranked environmental regulations (and in particular waste disposal regulations) as their most serious problem and were critical of the rigidity of the command-orientated regulatory system (Schmitz, Boggess and Tefertiller 1995).

It would seem that there may be some relocation of specific sectors within agriculture (particularly those involving livestock production), away from areas with strict environmental regulations. But it appears that the driving force is more toward regions of greater assimilative capacity than to where environmental standards are lax. This shift then, would be optimal.

Tobey (1991)[23] comments that trade competitive losses in agriculture are likely to be modest, and he gives several reasons for this. Firstly, 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 market share in most of these exported goods. Thirdly, any competitiveness effect is likely to be overshadowed by more significant forces such as movements in exchange rates, shifts in consumer demand for agricultural commodities, differentials in labour costs, and health and safety standards (OECD 1994; Tobey 1991). Jaffe *et al* (1995), when looking at the industrial sector, includes with the above determinants, differences in the cost of energy and raw materials, and strength of the infrastructure, saying that all of these would overwhelm the environmental effect.

2.6 Alternative Views on the Issue of Competitiveness

Adhering to a very different viewpoint, Porter and van der Linde (1995) criticise the traditional approach of dealing with environmental goals and industrial competitiveness as a trade off between social benefits and private costs. Their criticism of the theoretical argument of loss of competitiveness is that it "grows out of a static view of environmental regulation, in which technology, products, processes and customers needs are all fixed. In this static world, where firms have already made their cost-minimising choices, environmental regulation inevitably raises costs and will tend to reduce the market share of domestic companies on global markets" (Porter and van der Linde 1995, 97). They argue that "competitive advantage rests not on static efficiency nor on optimising within fixed constraints, but on the capacity for innovation and improvement that shifts the constraints" (Porter and van der Linde 1995, 98). For this reason they question the studies set within a static framework which ignore possible innovation benefits and so over-estimate net compliance costs. They maintain that many well-designed environmental standards could stimulate innovation that may improve productivity

[23] Cited in Ervin and Fox (1998).

through better utilisation of resources. Alternatively, innovation might reduce disposal costs, or create higher-quality products, safer products or even lower-cost products. Porter and van der Linde call these 'innovation offsets' as they partially offset costs of compliance. The studies by Boggess, Johns and Meline (1997), Schmitz, Boggess and Tefertiller (1995) and Parminter (1998)[24] show improved productivity as a direct result of change in the method of waste disposal in order to comply with an environmental regulation. Porter and van der Linde (1995, 98) boldly suggest that "by stimulating innovation, strict environmental regulations can actually enhance competitiveness".

Increasingly, private firms are not necessarily waiting for Governments to impose environmental regulations. Perceiving the benefits to outweigh the costs, they are adopting their own environmental management practices. There is cost saving through reduction of production waste, and the avoidance of regulatory penalties as regulations come into force. Further, they are responding to demand-pull forces. In response to consumer demand, firms that have high standards on environmental issues are able to enter lucrative green markets and ensure access to global markets (Ervin and Fox 1998).

Paul Krugman (1996) would prefer dispensing with the whole idea of intercountry competitiveness altogether in this, or any other context. He maintains that "obsession with competitiveness is not only wrong but dangerous, skewing domestic policies and threatening the international economic system" (Krugman 1996, 5). He says that one cannot compare nations in a competitive sense as one would compare corporations like Pepsi and Coca-Cola. Corporations can go out of business, countries cannot. Where corporations are in direct competition, one succeeds at the expense of the other, but almost the opposite is true for nations. A successful and growing Japanese economy aids New Zealand's growth by providing us with larger markets for our export goods and providing quality imports at lower prices. In the same way, the downturn in the Asian economies did not mean that we saw an immediate increase in our economic growth, instead, it had a negative effect on our growth rate. "International trade, then is not a zero-sum game" (Krugman 1996,

[24] See Chapter Three for detail on Parminter's study.

10). Krugman suggests that the argument of competitiveness is likely to be put forward in an effort to try and get trade protection, whether it be environmentally driven or some other issue. He puts forward three reasons to support his claim that the obsession with competitiveness is dangerous. The first is that some research and development effort is wasted supposedly enhancing a country's competitiveness. Secondly, obsession with competitiveness could result in harmful public policy decisions being made, and thirdly, it could lead to protectionism and trade wars.

Bhagwati (1996), Ervin and Fox (1998), and Anderson (1998) say that it is not the level of stringency of the environmental regulations that affects competitiveness, but rather the degree to which the environmental costs are internalised. "Government subsidies which compensate firms for the cost of meeting regulations inhibit the optimal shift of resources away from pollution-intensive industries" (Dean 1992, 20). Also, less polluting production technologies are unlikely to be adopted without optimal environmental taxes providing the incentive (Blom 1996). When the price of a traded commodity does not accurately reflect the opportunity cost of some environmental resource employed in the production of that good, then the producing country gains a false comparative advantage through a distortion acting to all intents and purposes like a subsidy (Ervin and Fox 1998).

2.7 Environmental Standards as a form of Protectionism

In 1990 Runge suggested that environmental policies might become the next generation of protectionism. A protectionism based on non-tariff barriers, under the guise of objectives linked to health, quality, environment and ethics (Mahe 1997). "Pollution abatement regulations and taxes, waste disposal schemes and even ecolabelling have been viewed as new ways to discriminate between products from different sources. The main clash in this area arises in distinguishing between legitimate domestic standards and disguised trade barriers" (Uimonen and Whalley 1997, 33). The concern is that environmental policies will be used as a covert way of protecting domestic producers, impacting on trade and international competitiveness and contrary to GATT rules (Anderson and Blackhurst 1992; Ferrantino 1997).

Ervin and Fox (1998) point out that there are two general exceptions from a country's GATT requirements with regard to its environment. These exceptions, found in Article XX of the GATT allow for a country to put in place steps necessary firstly to "protect human, animal or plant life or health". And secondly "relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption". These actions must avoid unnecessary trade interference. Many are environmentally related product standards concerning things like food products, motor vehicle emissions, toxic substance controls, and packaging requirements. Sanitary and Phytosanitary (SPS) measures, since they include animal/plant life and health measures, pertain to the natural environment. They use inspection, certification and approval procedures, quarantine treatments and the like, and have the potential to affect agricultural trade (Ervin and Fox 1998). With these, the country with the stringent regulations, will find that instead of a deterioration in its comparative advantage, "its competitive position will be enhanced, as imported goods which fail to meet the local standards are prohibited" (Dean 1992, 22). Uimonen and Whalley (1997) give the example of the EU's ban on beef imported from the US because of the growth hormones used in raising US cattle. The EU said the motivation was to protect public health, but the US asserted that since their beef exports contained no detectable hormone residues, the trade barrier was unfair.

"Waste control and recycling measures are also being scrutinised for unnecessary barriers to trade" (Uimonen and Whalley 1997, 33). For example, the imposition of a 10-cent per can 'environmental' tax on non-refillable beer cans by Ontario, Canada. This was considered a protectionism measure for several reasons. Firstly, the tax came into effect in 1992 after a number of disputes over beer trade and distribution between Canada and the US. Secondly, US beer is distributed in cans while Canadian beer is distributed in bottles, and lastly, the tax does not apply to other products sold in cans.

The European Union Council regulations allow environmental subsidies for agriculture. Examples of these are subsidies to reduce the use of fertiliser and pesticides, to assist organic farming and to promote production methods that are environmentally 'friendly' (Anderson 1998). This is a straight substitution for traditional protectionism.

Eco-labelling could be viewed as a nontariff barrier (Hewison 1995). Mandatory eco-labelling[25] can cause trade disputes if they appear to discriminate between products from different countries. Ferrantino suggests that developing countries fear that "an ecolabel is simply a protectionist trade measure under less transparent means. The requirements for getting the 'green' label being either unpublicised or crafted in such a way as to place a disproportionate burden on the imported rather than the domestic product" (Ferrantino 1997, 69).

Bhagwati (1996), Charnovitz (1996), and Uimonen and Whalley (1997) also discuss value-related environmental issues, where objection is made to production and processing methods. The EU has considered a regulation banning the domestic use of steel leg-hold traps when trapping animals for their fur, and also banning the import of furs from countries like Russia, Canada and the US which also use such traps. Some European countries (e.g., the Netherlands) have contemplated restrictions on the importation of unsustainable tropical timber. To date such regulations have not been implemented (Uimonen and Whalley 1997). Also the US threatened trade sanctions against China and Taiwan as long as they continued importing products derived from tigers and rhinoceroses[26].

The issue of 'environmentally-friendly' production and processing methods is likely to become increasingly important for agriculture. Ballenger and Krissoff (1996) use the example of pesticide regulations. They suggest that the emphasis is likely to shift from being an issue about residues affecting soil and water quality, to the question of what quantity of pesticide should be used in production, if at all. Further, trade issues are likely to be overtaken by broader concerns regarding "land use, including deforestation, wildlife protection, and genetic diversity – issues that will interface more directly with production agriculture" (Ballenger and Krissoff 1996, 74).

Charnovitz (1996) maintains that if a consumer wants to include values in decision-making, then these issues become a valid part of their tastes and preferences and hence are part of the free market. The perception might be that ecolabelling falls into

[25] E.g., warning labels on tobacco products, and labels identifying products as containing tropical timber.
[26] Both animals have been designated as endangered species under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

this category. Thus 'ozone-friendly', 'dolphin-friendly', 'made without the use of child labour', becomes part of the consumer's decision-making.

2.8 Conclusions

There has been 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, therefore regulations, standards and the cost to comply with these will also vary. The question is, will these regulatory differences affect international competitiveness?

Regulations certainly do impose large direct and indirect costs on society. However, empirical studies done on polluting industries have generally failed to show evidence to support the hypothesis that environmental stringency leads to loss of international competitiveness. Jaffe *et al* (1995) suggest several reasons for this. Existing data are limited in their ability to measure the relative stringency of different environmental regulations, making it difficult to assess the effect of stringency on economic performance. Secondly, many studies depend critically on accurate measurement of environmental spending even though compliance expenditure data are often unreliable. This problem is likely to be exacerbated as we move more toward performance-based environmental regulations. Spending for pollution control will increasingly take "the form of process changes and product re-formulations, rather than installation of end-of-pipe control equipment"(Jaffe *et al* 1995, 158). Thirdly, for most industries the cost of complying with environmental regulations is a small percentage of the total cost of production. Therefore it is likely that labour, energy, and raw material cost differences, infrastructure adequacy, and other factors would far outweigh any effect on competitiveness that might be brought about by environmental regulatory intensity. Another reason is that environmental standards among western industrial democracies do not differ significantly, particularly those pertaining to air and water quality. However there is the difficulty of measuring the effectiveness of enforcement efforts and it may be these differences that have the potential to influence competitiveness (Jaffe *et al* 1995).

Outside the western democracies, environmental requirements do differ enormously. The concern has been that these substantial differences both in standards and in social preferences might lead to a reallocation of pollution-intensive industry to a jurisdiction with lower standards. This fear seems to be largely unfounded. Increasingly, new equipment and processes are designed to be less polluting and multinationals tend to use these technologies and processes irrespective of the location.

The other argument is that any serious effort to measure the competitiveness effects associated with an environmental regulation needs to evaluate all the costs and benefits attributed to that regulation. Environmental standards could stimulate innovation that may lead to improved productivity, improved products, or lower disposal costs. Ignoring these would lead to an over estimate of net compliance costs. Jaffe *et al* (1995, 159) state that "just as we have found little consistent empirical evidence for the conventional hypothesis regarding environmental regulation and competitiveness, there is also little or no evidence supporting the revisionist hypothesis that environmental regulation stimulates innovation and improves international competitiveness".

The other concern is that environmental policies could be used as a form of protectionism, protecting domestic producers. This also would impact on trade and international competitiveness.

More recently studies have been done in the agricultural sector to calculate the additional cost incurred to meet environmental standards. These are done at the micro level, estimating the increased cost attributed to specific regulations for an individual section within the agricultural sector. Some go a step further and use modelling to look at the effect of this increased cost on production of this good, on reallocation of resources, and consequently on the production of other goods. A few also look at the effect on exports and world prices.

This research aims to test some of these findings by concentrating on just one part of a piece of legislation and estimating its impact on a subsector of New Zealand agriculture. This investigation will look at the impact of the water quality regulations set down in the Resource Management Act, 1991 (RMA 1991) on the New Zealand dairy sector. It will observe the level of enforcement carried out at the regional level and calculate the additional costs incurred to the dairy farmer. Data will be collected that will support or refute the possibility of improved productivity as a direct outcome of the water quality regulations, which may partially offset some of the additional costs.

A CGE model (GTAP) will be used to look at the effect of increased costs on the level of production in the dairy sector. It will also observe any shift of resources and any change in the level of production in other sectors. This study aims to test the hypothesis that enforced environmental regulations impose measurable cost on the domestic industry and therefore reduces its international competitiveness.

There will also be an investigation into the premise that environmental standards pertaining to air and water quality among western industrial democracies do not differ significantly. However, what may differ is the level of enforcement and government assistance given to meet these standards, and it may be these differences that have the potential to influence competitiveness. Research into these differences will be done for the other principal dairy exporting regions, namely the EU, Australia, and the US. Examination into the possible effect on competitiveness of these differences will be carried out.

Chapter Three

New Zealand Dairy Sector Compliance Costs for Water Quality Regulations

3.1 Introduction

In this chapter, the additional costs to comply with current water quality regulations are estimated for the New Zealand dairy sector. This necessitates looking at the response each Regional Council has made to these regulations, and the requirements they have placed on the dairy farms in their region. Regional variations in the costs of compliance are taken into account. In order to improve both surface and ground water quality in dairy farming areas, there has been a nationwide move toward the application of farm dairy effluent to land. For this reason, estimates have been made as to the cost all New Zealand dairy farms have accrued, operating land-based effluent disposal systems. 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 pasture two or three times a year. A sensitivity analysis has been done on these cost estimates. In it the two land disposal methods are considered, with or without the inclusion of fertiliser and possible productivity benefits, and also with variations in interest rates for capital cost borrowing. The estimated costs of compliance with the water quality regulations are expressed as a percentage of the dairy farmers' total costs, and as a total annual cost to the dairy sector.

3.2 Water Quality Regulations and Variations in their Administration across Regional Councils

3.2.1 Water quality regulations

Recent years have seen an increase in the number of dairy farms discharging effluent onto land. Previously, most discharge of dairy effluent was to water, the control of which was the responsibility of Catchment Boards, under the Water and Soil

Conservation Act, 1967. However local government reform in the late 1980's shifted this responsibility to the Regional Councils. Since 1991, discharges to water or land have become subject to the requirements of the Resource Management Act, 1991 (RMA 1991, or the Act). Under the RMA 1991, discharges to water are not allowed unless they are specifically permitted in a regional plan, or allowed by a consent issued by the relevant Regional Council. Discharges to land are allowed provided they do not contravene the provisions allowed for in a regional plan, and do not result in a contaminant entering surface or ground water. Details of the relevant sections of the RMA 1991 may be found in Appendix 1.

3.2.2 Variations across Regional Councils on consent requirements

The RMA 1991 provides Regional Councils with some flexibility in how they administer and enforce the Act. Thus differences have been observed between regions as to how strongly the discharge of dairy effluent to water is discouraged. In some areas, like East Coast, there are so few dairy farms that it is just not an issue. In other areas soil types and hence absorption capacities, vary significantly within the region. Consequently applications for consent must be dealt with on a case-by-case basis. This is so in the Manawatu where, for example, the heavy soil around the Bunnythorpe area does not drain freely and hence is prone to ponding, while toward the coast, not many kilometres away, the soil is sandy and free-draining and better accommodates all-season discharge of dairy effluent to land.

South Auckland is the largest dairy farming region in the country, producing 31% of New Zealand's total milk output. This area comes under the Waikato Regional Council (WRC, or Environment Waikato) which has been proactive, using economic incentives to encourage dairy farmers to put in place land-based effluent disposal systems. The motivation was to improve surface water quality, in the dairying areas, which was documented as being of low quality, primarily on account of effluent discharges and runoff from farms (Smith *et al* 1993). Poor water quality was believed to compromise the value of some lakes, rivers and streams in the region. further motivation was to protect ground water quality which, in the Hamilton Basin, exhibited high nitrate levels[27].

[27] In a survey conducted in the 1980's over 30% of bores in the Hamilton Basin had more than 10 mg/m^3 of nitrate-nitrogen, which is the World Health Authority recommended maximum (Hoare, 1986).

Environment Waikato has made the application of farm dairy effluent onto land, a permitted activity under the Act, provided certain conditions are met[28]. As a permitted activity, no consent is required, and no annual fees are payable. Other discharges to land, and discharges from treatment systems to water, require a resource consent. AgriQualityNZ officers carry out annual inspections to monitor compliance with regional rules. The economic incentives are strengthened by an educational programme of published information and by advice to farmers through the Council's field staff (Parminter 1998).

Four other regions have also made the land-based disposal of dairy effluent a permitted activity[29]. Two of these regions have areas within their boundaries where land-based discharge of dairy effluent is not a permitted activity. In Northland the exception is the Bay of Islands, where all farm dairy disposal requires a resource consent to maintain groundwater water quality as well as maintain surface water and coastal waters to contact recreation standard. Otago too, has made the application of farm dairy effluent to land a permitted activity, with some exceptions. Parts of its region are classified as groundwater protection areas (for example Waitake) and where this is the case, a consent is required.

Taranaki is the second largest dairy farming region, producing 15% of the country's total milk output. The discharge of all farm dairy effluent (whether to land or water) requires a resource consent in Taranaki. This is also the case in seven other regions around the country. Taranaki though, is unique in that some 1600 of its dairy farms currently hold a consent to discharge effluent to either land or water. These farms have oxidation ponds and some farmers may spread effluent from their second pond directly onto land at certain times of the year. However, the effluent from the majority of these ponds goes directly into water bodies, or seeps into the surrounding ground.

There are noticeable differences across the regions, in the percentage of dairy farms which are now discharging their farm dairy effluent to .land. In areas like

[28] These conditions are detailed in Appendix 2.
[29] These also have set conditions similar to those outlined in Appendix 2.

Canterbury, Otago and Hawkes Bay, which are not traditionally dairy farming regions, the Regional Councils have been able to make land-based disposal a requirement for new dairy farms. Where existing dairy farms hold a consent to discharge effluent to water, these are unlikely to be renewed when the consent expires. For some regions the transition from water discharge to land discharge will be considerably slower. Nevertheless, by the end of 1998 approximately 70% of New Zealand dairy farms were discharging dairy shed effluent to land.

3.2.3 Variations in compliance costs

The cost of a consent, and the on-going cost of monitoring also varies from region to region, depending on whether or not it is partially subsidised by the Regional Council as a compliance incentive to the farmer. Minimum application fees for a resource consent vary from $120 to $562.50 with actual costs for officer time, travel and administration usually being added to this. Where land-based effluent treatment is given permitted activity status, there is no initial cost to the farmer. The Auckland Regional Council is the only Regional Council that attaches an annual fee to its permitted activity, over and above its somewhat minimal monitoring cost.

Some regions require annual inspection and the monitoring of farm dairy effluent disposal systems. Others reduce this to every second year (or even less frequently) where a farmer is operating a good effective system. Again monitoring costs to the farmer vary from $200 annually, to being totally subsidised by the Regional Council.

Table 3.1 gives a summary of the data from each region. It indicates which regions require a consent for the land-based discharge of farm dairy effluent and gives an estimate of the percentage of dairy farms in the region which are currently discharging their effluent to land. Costs given for consent and monitoring are 1998 costs and include 12.5% GST.

Table 3.1 Consents, Monitoring, Costs, and Compliance for the Dairy Regions of New Zealand

Region	Number of Dairy Herds	Consent required or permitted activity for land-disposal system	Cost of Consent[1]	Duration Of Consent (years)	Number of Inspections per year	Annual Monitoring Costs	Estimate of % of farms with land-disposal systems by late 1998
Northland	1,528	Permitted activity (exception: Bay of Islands)	- (Bay of Is: $337.50)	-	1* Bay of Is. 1	$67.20	76 – 89%
Central Auckland	839	Permitted activity	- (ann. $250-300)	unlimited	1*	$50	42%
South Auckland (& Central Plateau, Western Uplands)	5,531	Permitted – irrigator Consent – ponds	- $200 - 300	unlimited	0 after 3 clear yrs	- $243.15	70%
Bay of Plenty	830	Consent	$500	10 - 15	1	$200	80%
East Coast	19	Consent	just actual cost	varies	1	actual cost	-
Hawkes Bay	65	Consent	$562.50	10	1*	$154.56	97%
Taranaki	2509	Consent	$198.75	12 - 18	usually 1	$56	37% +
Manawatu/Wanganui	666	Consent	$400 - 500	20	1	$63 non-compl: $153	67 – 75%
Wellington (& Wairarapa)	672	Consent	$120	10	1*	$115	80%
Nelson/Marlborough	341	Permitted activity (is to change for Marl.)	-	10 – 15	1	-	84% 70-80% for Marl.
West Coast	371	Consent	$100 - 150	-	0 after initial	-	10%
Canterbury (North & South)	543	Permitted activity (for < 330 cows) Consent (>330 cows)	- $600 (appl. & visit)	max 35	varies with herd size & history	$200	90 – 95%
Otago	297	Permitted activity (except groundwater protection areas)	- (Waitake: $180)	-	1 every 5 yrs unless prob. 1	-	most
Southland	471	Consent (> 50 cows)	$250	10	1	$159	90%

[1] These are minimum application fees. Usually additional costs (including travel, actual officer time etc) are paid. Where a range has been given, this is an all-inclusive estimate.

* For good effective systems, inspections are cut back to once every two years.

3.2.4 Application rates of farm dairy effluent

The Regional Councils specify differing maximum application rates for dairy effluent irrigation onto land. Environment Waikato stipulates that, in general, the effluent loading be no more than 150 kilograms of nitrogen per hectare per year. It may be at a higher rate provided there is no elevation of ground water nitrogen concentrations such that existing, or reasonably forseeable uses of the receiving ground water, or surface water, would be compromised (Environment Waikato 1998a). Northland, Hawkes Bay, and West Coast Regional Councils as well as Marlborough District Council, also state that nitrogen loadings should not exceed 150 kg/ha/year. Taranki, Canterbury, Nelson and Auckland Regional Councils have 200 kg/ha/year as their maximum nitrogen loading, while the Bay of Plenty Regional Council has set theirs at 300 kg/ha/year. The aim of these requirements is to avoid the leaching of nitrogen into groundwater. Differences occur between the regions because the risk of leaching varies with soil type, weather conditions, depth of the water table, and vegetation cover. Leaching losses are highest in peat, pumice, sand and ash soils (Dairying and the Environmental Committee 1995).

3.3 Cost of Land-based Application of Dairy Shed Effluent

This study looks at two methods commonly used in the application of farm dairy effluent to land. Raw waste from the dairy shed may be stored briefly in a sump and irrigated onto pastures daily. Alternatively, the waste may be stored in ponds and the contents spread onto pasture two or three times a year. The first method, involving daily irrigation of the effluent, usually requires a pump, hose, and sprinkler system. Travelling irrigators are recommended in preference to 'pot spreaders' which require shifting at regular intervals. Storage facilities (a sump or pond) allow the effluent to be held for a number of days, when soil conditions are not suitable for effluent irrigation. This would typically be during extended spells of wet weather when the soil is saturated.

An alternative land-based system, is where the effluent is stored in ponds and spread on the pasture two or three times per year. This method utilises a transportable tanker or effluent wagon to spread the dairy shed waste. The fertiliser value of the effluent is lower after storage, but this method has some advantages. Most importantly, it allows for irrigation of the effluent when soil conditions are most favourable. Also, application to any part of the farm is possible, including ground unsuitable for travelling irrigators.

In order to estimate the cost to the New Zealand dairy industry of complying with current water quality regulations, a number of assumptions have been made. It has been assumed that all dairy farms in New Zealand will dispose of their dairy shed effluent with a land-based disposal system, and that they will operate either a travelling irrigator or a pond storage system from which effluent is spread. In some regions land-based effluent disposal is a permitted activity, whereas in other regions, a consent is required. Where a consent is necessary, it is assumed that the cost of consent is financed through the loan and that consent renewal will be required after 15 years. In reality this time period varies from region to region, but the variation has negligible effect on annual loan repayments.

Throughout the different regions average herd sizes range from 172 cows in Northland to 487 cows in Waitaki. For this reason estimated costs were used for two herd sizes, a 150 – 249 cow herd and a 250 – 549 cow herd. For farms on flat to gently rolling country, construction costs for a travelling irrigator system were estimated to be $18,000 for a 150 – 249 cow herd, and $25,000 for the larger herd. Both these figures increase by $8,000 on steeper country. Annual operating costs are estimated at $1000 for the smaller herd and $1450 for the larger herd[30]. A breakdown of all these costs can be seen in Appendix 3, Tables A3.1 and A3.2. A travelling irrigator system could be expected to last about 15 years before the pump, irrigator, hydrants and piping need replacing.

The alternative system, where effluent is stored in ponds and spread on the pasture two or three times a year, requires much less capital, but annual operating costs are significantly higher than for the irrigator system. For a two-pond system, construction costs are approximately $4,500. The life of these ponds is roughly thirty years, but since the capital cost is relatively small, it makes little difference to annual loan payments whether the term of the loan is 15 or 30 years. For this reason the term of the loan has been left at 15 years to better fit with the duration of resource

[30] Both operating figures increase by $400 on steeper farmland, due to increases in repairs and maintenance, which are estimated as a percentage of the cost of the pump and irrigator.

consents. The cost for emptying the ponds and spreading the effluent on the pasture, is estimated at $3,900 for a 150 – 249 cow herd, and $7,000 for a 250 – 549 cow herd[31].

3.4 Benefits from Application of Farm Dairy Effluent to Land

There is uncertainty and a degree of scepticism regarding the fertiliser value and possible increase in productivity attributable to land-based disposal of dairy shed effluent. "The nutrient content of farm dairy effluent, and the volume generated, are highly variable, both between farms, and between months and seasons on the same farm. Feed quality and quantity, the amount of water used for washing down, and the handling of cows in the farm dairy causes variation in the volume and nutrient content of effluent generated, even in the same herd" (Parminter 1998, 5). However, the application to land of effluent, has the potential to reduce the amount of fertiliser required. Raw effluent[32] has been estimated to contain 10.4g/cow/day of nitrogen, 1.76g/cow/day of phosphorus, and 8g/cow/day of potassium (Vanderholm 1984). The value of the equivalent quantity of fertiliser has been estimated at $290/ha[33]. This has been reduced to $218/ha (Parminter 1998) for the following reasons. Firstly, not all the nutrients in raw effluent are able to be utilised even if the effluent is applied to land almost immediately, and secondly, volatilisation of ammonia-N from the ground's surface reduces the amount available to plants by 10 – 30% (Cameron and Rate 1992; Lincoln Environmental 1997). Where effluent application rates are too high, nutrients may flow through the soil and be lost to groundwater (Singleton 1995). Alternatively, they may build up in the soil in forms not immediately available to plants.

There is also the possibility that 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.

[31] Details are given in Appendix 3, Table A3.3.
[32] Raw effluent is distinguished from effluent stored for some time, because raw effluent has a higher nutrient content than that of stored effluent.
[33] This is based on the assumption of 0.04%, 0.008% and 0.03% contents of nitrogen, phosphorus and potassium respectively (Waikato Regional Council, 1997).

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[34]. 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[35]. Appendix 3, Table A3.4 details how the annual benefit figures have been estimated.

3.5 Sensitivity Analysis

Environmental regulations, as stipulated in the RMA 1991 have on the whole, required dairy farms to cease discharging their effluent directly to waterways in favour of a land-based effluent treatment system. To estimate the cost imposed on the dairy sector by these regulations, the assumption has been made that all New Zealand dairy farms will utilise a land-based disposal system for the treatment of their dairy shed effluent. Costings have been done for both the travelling irrigator system (on both flatter and steeper terrain) and tanker spread effluent from the pond storage system. The reason for this is that an estimated 60% of New Zealand dairy farms are located on imperfectly drained soils. These farms are better suited to a storage system where effluent can be held until the soil is less waterlogged and more able to absorb the application of effluent from the farm dairy.

Both capital and consent costs have been funded by a fifteen year loan. The sensitivity analysis includes calculations for interest rates on the loan of both 9% and 7%. Regional differences in cost of both resource consents and on-going monitoring of regulatory compliance have been taken into account.

Since uncertainty and some scepticism surrounds the fertiliser value, and possible increased productivity, of the application of farm dairy effluent to land, the sensitivity analysis also includes estimations with, and without, the inclusion of annual benefit estimates.

3.6 Results

[34] Calculations were done for the MAF Farm Monitoring Waikato/South Auckland model dairy farm which milks 196 cows (MAF, 1997), though the model has recently been adjusted to more closely reflect the mean size of dairy farms in the Waikato region.

Total additional production costs incurred when dairy farms comply with water quality regulations have been calculated for all New Zealand dairy farms. This cost has been expressed as a percentage of the dairy farmers' total production costs[36]. Tables 3.2 and 3.3 presents the sensitivity analysis estimates.

Table 3.2 Costs of Regulatory Compliance using a Travelling Irrigator

Compliance Costs	flat to rolling farmland	steeper farmland
National Net Cost ($million) - annual benefits included	17.9[1)] (21.9)	30.8 (36.4)
National Cost ($million) - excluding annual benefits	46.9 (50.9)	59.8 (65.5)
National Net Cost (as % of total farm costs) - annual benefits included	0.51% (0.63%)	0.88% (1.04%)
National Cost (as % of total farm costs) - excluding annual benefits	1.34% (1.46%)	1.71% (1.87%)

[1)]Front figures calculated using an interest rate of 7%, figures in parentheses have been calculated using a 9% interest rate.

Table 3.3 Costs of Regulatory Compliance using Tanker Spread Effluent from a Pond Storage System

Compliance Costs	7% Interest rate	9% Interest rate
National Net Cost ($million) - annual benefits included	53.8	54.8
National Cost ($million) - excluding annual benefits	73.2	74.2
National Net Cost (as % of total farm costs) - annual benefits included	3.05%	3.11%
National Cost (as % of total farm costs) - excluding annual benefits	4.14%	4.19%

[35] Again this is for the model farm. These figures have assumed a 270 day season and an average washdown volume of 50 litres/cow/day to achieve the 150kg N/ha/season.
[36] These costs are given in Appendix 3, Table A3.5.

These figures have been weighted in a 40:60 ratio between the use of irrigators and pond storage system. The reason for this being that, as previously stated, approximately 60% of New Zealand dairy farms are located on imperfectly drained soils and so 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 the water quality regulations therefore lies between $39.4 million and $67.8 million. The cost to the dairy farmer, as a percentage of his total cost, lies between 2.0% and 3.2%.

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 and labour. There are the capital costs incurred setting up the new equipment, either irrigator or ponds. Also included in capital are the consent costs, since these have been financed within the loan. Furthermore, there are labour costs associated with installation and with the on-going operation of the land-disposal effluent systems. These are particularly significant with the pond system which requires spreading of the effluent, by tanker over the farmland. 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[37], respectively.

Table 3.4 Percentage of Costs attributable to Water Quality Compliance

Disposal System	Percentage of Capital Costs	Percentage of Unskilled Labour Costs
Travelling Irrigator - flat to rolling farmland	4.77%[1)] (5.25%)	4.50% (4.72%)
Travelling Irrigator - steeper farmland	7.30% (8.00%)	4.50% (4.72%)
Pond storage system	1.38% (1.52%)	29.27%

[1)]Front figures have been calculated using an interest rate of 7%, figures in parentheses have been calculated using a 9% interest rate.

[37] Total capital costs and unskilled labour costs (given as wages) are given in Appendix 3, Table A3.5.

For farms using the irrigator system, an average of the flat to rolling and steeper farmland costs was taken. Then once again the 40:60 weighting was applied between the irrigator and the pond storage system. The nation-wide estimate of the percentage of a dairy farm's total capital cost attributable to water quality compliance, lies between 3.2% and 3.6%. For unskilled labour costs the figures are much higher, with the estimate being 19.4 – 19.5% of a farm's total unskilled labour costs.

Table 3.1 gives the regional estimates of the proportion of dairy farms that were operating a land-based effluent disposal system by the end of 1998. From these it was estimated that approximately 70% of all New Zealand dairy farms were operating such an effluent disposal systems by the end of 1998. Therefore with some 30% still to comply, it would cost the dairy sector a further $11.8 million to $20.3 million in order for all farms to be disposing of farm dairy effluent to land.

The proportion of dairy farms disposing of effluent to land, rather than to water, in 1995 is known for some, but not all regions. In South Auckland, which produces 31% of New Zealand's total milk output, approximately 50% of dairy farms used land disposal of effluent by 1995. This proportion was about 32% for Taranaki dairy farms, and in Northland, 50% of dairy farms had good or adequate land-based systems and a further 33% were categorised as marginal with minor or potential problems only. At the end of 1998, South Auckland was a good indicator for the whole of New Zealand because approximately 70% of dairy farms in the region operated land-based effluent disposal. This was the same as the nation-wide estimate which was also 70%. For this reason the 1995 proportion of South Auckland dairy farms operating land-based effluent disposal systems has been used as the nation-wide estimate of dairy farms disposing their effluent to land. Based on South Auckland then, it is estimated that approximately half of New Zealand dairy farms were operating a land-based disposal system for their farm dairy effluent in 1995. This estimate will be used in the analysis of trade impacts of the water quality regulations.

Chapter Four

Australia, the EU, and the US - Regulations, Costs and Subsidies

4.1 Introduction

As well as investigating the cost to the New Zealand dairy sector of compliance with water quality standards as outlined in the RMA 1991, this research also addresses the issue of whether these costs might affect New Zealand's competitiveness in the global market for dairy products.

Of interest to a small open economy like New Zealand, is whether her competitors face similar issues at similar cost, and who pays these costs. This chapter answers these questions for the other three principal dairy exporters. These are the EU, which in 1996 had 45% of the world dairy export market, Australia, with 11%, and the US, with 3% of the market[38] (New Zealand Dairy Board 1998a). Each region is looked at separately. Water quality regulations are outlined, and any studies done on the compliance costs incurred in meeting these regulations are discussed. Lastly, a summary of relevant government assistance is given.

4.2 Australia

4.2.1 Background and water quality regulations

While insignificant as a milk producer at the global level, Australia trails only the EU and New Zealand in volume of exports of milk products. Producing only 2% of world milk in 1995-96, but exporting approximately 45% of its total production, meant that Australia accounted for 10% of world milk export sales during this period (Industry Commission 1997).

[38] New Zealand was the second largest dairy exporter, with 29% of the global market.

On Australian dairy farms, cattle graze outdoors on pasture. Stocking rates are low as a result of low rainfall and poor soils. Furthermore, Australia is one of the least densely populated countries in the world, with most people concentrated in urban areas in the coastal regions. More than 80% of the population lives on just 1% of the country's land surface, which means fewer conflicts between urban communities and agriculture.

Australia's water reforms tend to address issues of scarcity through water pricing reform, clarification of property rights, allocation of water to the environment and adoption of water trading arrangements. The quality of drinking water in Australia has never been a major concern and the actual risk to health relating directly to water supplies has never been quantified (Maher *et al* 1997). Health risks to humans and livestock presented by organic chemical contaminants from human activity are rare, and naturally occurring nitrates have seldom been a problem. Nevertheless, the 'Australia drinking water guidelines' are widely used as a benchmark for water quality. The 'guideline level' set for nitrate in drinking water is 50mg/litre (NHMRC/ARMCANZ, 1996). In some areas animal production is increasing in intensity and effluent management guidelines for dairy processing have been developed for areas where water bodies are being affected by intensive dairy activities.

4.2.2 Compliance costs

Literature to date suggests that on-farm costs of compliance with environmental policies are not a significant issue in Australia. This is so for policies regarding dairy farming and its impact on water quality. At present policy response to water pollution is most often in the form of education, community participation, dissemination of research and the development of codes of practice.

What is significant is that the cost of water is very likely to increase as further water policy reforms are enacted and as market forces dictate the price for water. In 1996/97 the cost of water made up 2.3% of a dairy farmer's total cost, just marginally higher than the percentage of the cost of livestock.purchases (Australian Bureau of Statistics 1998). As water prices rise, some dairy farmers are expected to sell their properties, effectively transferring water to higher value uses.

4.2.3 Government assistance

In Australia the agricultural sector receives assistance from a wide range of government programmes and policies. The level of this assistance is low however, in comparison to other OECD countries (except New Zealand), with the producer subsidy equivalent (PSE)[39] for agriculture being 10% (OECD 1998b). For the most part, this assistance has begun to decline in the last ten years but this is not the case for the dairy industry which still enjoys a level of assistance greatly in excess of that received by all other parts of the agricultural sector. The nominal rate of assistance for market milk production (fresh or drinking milk) rose from 54% in 1995-96 to 60% a year later, while the effective rate of assistance increased from an already staggering 200%. Assistance to market milk comes from State governments setting farm gate prices and rationing production through quotas. For manufacturing milk (used to produce dairy products), the effective rate of assistance increased from 20% to 21% in the same period (Productivity Commission 1998). Most assistance for manufacturing milk comes from the Domestic Market Support Scheme. As part of this scheme, a levy is applied to all milk produced (both market and manufacturing milk). Producers receive a full rebate for the levy on the manufacturing milk that is used to produce dairy products sold on the export market. For dairy products sold on the domestic market, producers can pass on the cost of this levy to the consumer. The funds raised by the levy are used to pay a subsidy on all manufacturing milk. The subsidy rates are being reduced and are due to end on 30 June 2000. For the dairy sector in total, the effective rate of assistance was 58% for 1996-97, which if it was excluded from the assistance for the agricultural sector overall, the effective rate of assistance would decrease from 10% to 6% (Productivity Commission 1998). In Australia the 1998 provisional PSE figure for milk production is 31% (OECD 1999).

4.3 The European Union

4.3.1 Background and water quality regulations

In marked contrast to Australia and New Zealand, farming in the EU is intensive. The average farm size is less than 20 hectares and mixed farming is commonplace. Fresh milk comprises approximately 17% of final agricultural production. The dairy

[39] For a detailed explanation of PSEs, refer to Chapter One.

sector has been undergoing change in the last two or three decades. The move has been to fewer holdings with larger herds and increased production per cow. Since the introduction of a milk quota[40] in 1984, the number of dairy cows has reduced by more than one quarter. Average milk production per cow has increased from 4.4 tonnes (1986) to 5.4 tonnes (1997) and the export of dairy products from the EU has doubled since 1986.

Nitrogen pollution resulting from agricultural activity is a major threat to the quality of ground, surface, and marine waters in Western Europe. This is particularly so where there is intensive livestock production or large areas of specialised cropping and consequently high levels of manure and chemical fertiliser use. To cite examples, groundwater in Denmark, the sole source of drinking water, consistently exceeds the maximum allowable nitrate levels of 50 mg/litre in some regions. For the country as a whole, nitrogen application to land is roughly twice the level of nitrogen uptake through agriculture resulting in serious eutrophication of lakes and marine habitats. In the Netherlands, production rates of manure per hectare of farmland are five times the EU average, creating serious ground and surface water pollution by nitrates and phosphates. Consequently 40% of Dutch groundwater samples exceed 50 mg/litre of nitrate. In France 12% of drinking water samples exceed 50 mg/litre of nitrate, as do 10% in Germany. Nitrate pollution of surface water is a serious problem for some countries in the EU, particularly in the northern part of Western Europe[41] where nitrate pollution results from intensive agriculture and is exacerbated by high rainfall (CEC 1998). Further, excess phosphate from manure is causing eutrophication along the Baltic and Adriatic coasts.

The most significant standard that addresses this issue for Europe as a whole, is the Council Directive 91/676/EEC of 12 December 1991 (Official Journal of the European Communities 1991). This is concerned with the protection of waters against pollution caused by nitrates from agricultural sources. Known as the Nitrate Directive, it aims "to reduce pollution of ground water (nitrates), surface water (eutrophication by excessive use of nitrogen and phosphate fertilisers), and the

[40] In order to stop farmers producing over their quota, milk produced beyond this quota is subject to a super levy equal to 115% of the target price.

atmosphere (emissions of ammonia)" (Brouwer *et al* 1999, 43). The maximum allowable limit of nitrate in both surface and ground waters is 50 mg per litre. Previously, this applied only to drinking water, but now under the Directive, this limit applies to all water sources. This is likely to require a reduction in stock density in these vulnerable zones, but this could simply mean relocating excess stock into an area, still within the country, where nitrate residue levels are lower than the maximum allowed. Alternative solutions are being researched ready to be implemented in 1999. These include substituting livestock feed away from imported protein meals (high in nitrogen content) toward lower nitrogen content grains. Farmers will be encouraged to move in this direction as the Common Agricultural Policy (CAP) reforms include reduction in grain prices (Leuck and Haley 1996).

The Directive has been phasing in a programme of action since 1995 and is aiming for full implementation by 2002. As with other EU environmental policy directives, the Nitrate Directive is binding as to the results to be achieved. However, it is left up to the Member States to choose the most appropriate form of implementation, and as a result standards vary widely. The water quality objective is Europe-wide, but is applied through zones identified to be vulnerable to the leaching of nitrate (Brouwer *et al* 1999). Such regions are called nitrate vulnerable zones (NVZs), and are designated at the member state level. For Denmark, Germany, and the Netherlands, the entire territory has been designated as vulnerable. However this does not necessarily indicate that for each of these three, the whole country is more seriously affected than other member states. Instead the decision may have been for uniformity across the whole country in order to save on monitoring costs. In NVZs there are limits on fertiliser use, and the application of livestock manure per hectare must not exceed 210 kg nitrogen per hectare by 1999 and 170 kg N/ha by 2003. Member States were to stipulate conditions relating to the available farm storage capacity of livestock manure. Similarly, member states were to have an action programme formulated by December 1995 and implemented by December 1999 (Meister 1995). These were to be compulsory within NVZs, and voluntary implementation was to be encouraged elsewhere. These action programmes include

[41] Including intensive dairy farming in western regions like Normandy, South-west England and Southern Ireland.

procedures for land application[42] of animal manure that aim to keep nutrient losses to water at an acceptable level (Brouwer *et al* 1999). In terms of enforcement the EU can, and has, taken action against those member states who have not met the provisions of the Directive, while the government of a member state can prosecute a farmer who does not comply with conditions set down for NVZs. Once NVZs are designated, the codes of good practice and the absolute limits on nitrogen applications, which apply within them, are fully binding.

4.3.2 Compliance costs

For the EU as a whole, few estimates have been made of the impact of policy measures on costs. To some extent, the cost of implementing the codes of good practice will be small since they are designed to avoid wastage and leaching of unused nutrients from farmland. However, the maximum application rates are binding and are expected to impose real costs. Furthermore, costs are likely to be greatest for dairy and beef farmers, because of the high cost of storage and distribution of livestock effluent. This could be serious in some NVZ areas where cattle farms are relatively small family concerns.

Brouwer *et al* (1999) assess the potential economic and environmental benefits of nutritional management measures in lessening nitrogen pollution from intensive livestock units in the EU. As part of this study they estimate the cost of the disposal of excess livestock manure. This is required in areas where the production of livestock manure exceeds the level of nitrogen per hectare allowed under the Nitrate Directive. Brouwer *et al* concentrate their research on the Netherlands, estimating the quantity of excess livestock manure produced. They then calculate the cost of processing and exporting this manure away from the holdings. It is their assessment that roughly one third of total manure production (from cattle, pigs, and poultry) needs to be processed or exported to comply with current application standards. The cost of this is estimated at 639 million ecu or 18.09 ecu/cubic metre of manure, or 2.07 ecu/kg of nitrogen[43]. Cattle produce about two-thirds of the livestock manure in the Netherlands. The nitrogen supplied from this cattle effluent is estimated to be

[42] Including rate and uniformity of spreading, capacity of manure storage vessels, periods when land application is prohibited, etc.
[43] 1 ecu = approximately $NZ0.49

341 million kilograms, of which approximately 40% is in excess. The Netherlands has one of the most serious problems of contamination of surface and ground water from livestock manure amongst the countries of the EU. Thus compliance costs in the Netherlands are high because of the large proportion of excess livestock manure produced and the high cost involved in its transportation.

The Nitrate Directive focuses on the assumption that manure from livestock is the primary source of the nitrate problem. Therefore it is likely that while policies resulting in agricultural practices meeting the standards of the Directive will reduce fertiliser use, they are likely to target intensive livestock production to a greater degree (Leuck *et al* 1995). One aspect of a study by Leuck *et al* (see Chapter Two for details) completed at the beginning of 1995 investigated the possible effect of the Nitrate Directive on livestock numbers in the EU. The key to their study was the idea that the level of residual nitrogen is a measure of the nitrate problem. Their suggestion was that livestock production should be reduced in proportion to the share of its contribution to the nitrate residual. Then any further reduction required to attain the nitrogen maximum annual residual (MAR) allowed by the Directive should be met by a decrease in fertiliser use. "Manure nitrogen comprises 82% and 77% of the nitrogen residual in Denmark and the Netherlands respectively. For Denmark, 82% of the 48,000-ton reduction in the nitrogen residual required, would be from livestock nitrogen[44]. The remainder of the residual would then be achieved with a 2.2% decrease in fertiliser use. Similarly, for the Netherlands, residual nitrogen would be reduced to the MAR with decreases in livestock production and fertiliser use of 65% and 28% respectively" (Leuck *et al* 1995, 11,12). Of particular interest is the reduction in livestock numbers across the whole of the EU, which would be required to achieve the MAR. These figures are given in Table 4.1.

[44] This represents 9% of total livestock nitrogen.

Table 4.1 Reductions in EU Livestock Numbers required to achieve the MAR

Livestock type:	Percentage reduction required
Dairy	7.8
Beef	4.8
Pigs	11.7
Poultry	10.1
Sheep	0.9

Source: Leuck *et al* 1995.

Environmental compliance costs, as a percentage of a farm's total costs are not available for the EU.

4.3.3 Government assistance

In 1998, the PSE for the EU's agricultural production was approximately 45%. Sheep, beef and milk boasted the highest level of government support. The PSE for milk was as high as 68% in 1990 but has slowly been reduced. The 1998 provisional figure for government support for milk production is 57% of total production (OECD 1999). Regarding environmental issues in agriculture, Member State governments have been implementing increasingly stringent regulations. However governments have been assisting farmers to meet these stricter regulations through education and advice. In some cases they have also assisted through direct grants where new regulations have required significant investment in new capital equipment on the farm.

4.4 The United States

4.4.1 Background and water quality regulations

The other significant player in the dairy export market is the US. While many countries import US dairy products, the primary importers are Mexico and Japan. There is a significant diversity in the structure of the dairy industry in different regions of the US. The upper Midwest and Northwest regions, the traditional dairy areas, have small holdings that grow their own feed, averaging 50 and 63 cows respectively. In contrast, the holdings in the new emerging dairy belt in the West and Southwest (California, Texas, Idaho and Washington) are much larger and more intensive in their dairy production, with the average herd size in the West being 283 cows (Kaiser and Morehart 1994). Dairy farms in the new dairy belt are 13% more productive than dairy farms in traditional regions and, as a consequence, national milk production has been increasing (USDA 1998). Total farm income is lowest in the Midwest, followed by the Northeast. The same is the case for variable costs and total cash costs. In the West, the returns to management and capital are double that for the Midwest and five times that of the Northeast.

Traditionally, farms and ranches have been exempt from the water, air, and land use regulations that have been imposed on other US industries. As with other developed countries, the polluter-pays principle has not applied to agriculture. Several reasons for this are likely. Firstly, there is the special political status that agriculture often enjoys, and secondly, there is the difficulty and cost of implementing compulsory measures. In the US, as elsewhere, environmental policies and programmes for agriculture have come about in response to documented problems, rather than as precautionary actions to prevent future damages. In the past these policies and programmes have come from the federal government but increasingly, state and local governments are taking action to control serious risk and damages in areas under their control (Ervin and Schmitz 1998).

Aggregate data show that poorly managed agriculture is the primary cause of surface water quality impairment nation-wide (Puckett, 1994; US EPA, 1995). The 1972 Clean Water Act (CWA) set goals of swimmable and fishable waters and since then federal, state, and local governments have contributed billions of dollars to the treatment of waste water. However, little has been invested in controlling emissions from some 2 million farms and ranches and, as a consequence, minimal progress has been made in reducing agricultural pollution to surface waters since the introduction of the CWA (Ervin, 1995). Some thirty-five thousand miles of impaired waters in twenty-two states can be attributed to animal operations (including cattle, pigs and poultry).

The limited documentation of groundwater contamination from agricultural sources points to excess nutrients, particularly nitrates from inorganic fertiliser and animal wastes.

Surface waters are protected from degradation from animal agriculture under the CWA. In 1987 it was amended to direct more effort to non-point sources, and as a result all states now have a federally approved non-point source management plan (Ribaudo, 1997). However state implementation is voluntary and progress has been slow.

Animal Feeding Operations (AFOs) are defined as areas where animals are confined and fed, or maintained, for a total of at least 45 days in any 12 month period and where crops or vegetation forage growth at the facility are not sustained during the normal growing season. There are several criteria for designating an AFO as a large confined Animal Feeding Operation (CAFO). It becomes a CAFO if more than 1000 animals are confined (large manure production). It is also designated CAFO if more than 300 animals are confined and wastes are discharged directly to water (an unacceptable condition). The final reason is if it is deemed to be a significant contributor to degradation of water quality, regardless of its size. Under the CWA, only CAFOs are considered point sources, and are therefore regulated. A CAFO requires a National Pollutant Discharge Elimination System (NPDES) permit. The permit can address a number of issues. It may necessitate the elimination of the discharge of animal wastes to water. It may also require a retention structure for animal wastes, periodic reporting of water quality monitoring results, proper land application of wastes, best management practices, and pollution prevention plans (US EPA 1998b). CAFOs represent a very small proportion of the AFOs in the dairy industry but the number is growing. All dairy CAFOs had a NPDES permit by 1992, but CAFO regulations have been changing in some states in the last few years. The remaining AFOs are usually only subject to voluntary programmes for the implementation of a nutrient management plan (NMP) to minimise adverse impacts on water quality and public health.

Eighteen states have been reviewed and of these half have some form of surface and groundwater protection. Fifteen states have mandatory design standards, eleven require a waste management plan and only nine require a specified separation distance from properties and water resources. Application standards vary with climatic and soil conditions. For example, manure cannot be applied within three days of forecasted rain in Alabama, and in the flood plains of Iowa, manure must be injected. In Texas, monitoring is really only done for farms discharging effluent directly into waterways. In California, action is usually only taken when a farm has been detected as polluting and in Arkansas, fines are not imposed despite violations. In an attempt to reduce the wide variation that occurs between states over the implementation and enforcement of point-source control programmes for animal facilities, the Unified National Strategy for Animal Feeding Operations was formed on 9 March 1999.

Pollution of groundwater is high on the agenda of public environmental concerns since it provides half of the population with drinking water and is the sole source for most rural communities. At least 12% of domestic wells in agricultural areas exceed the Maximum Contaminant Level (MCL) for nutrients (Mueller and Helsel 1996). The Safe Drinking Water Act (SDWA) protects the quality of groundwater, and the MCL for nitrate-nitrogen is 10mg/litre. Under the SDWA, CAFOs may be subject to additional discharge limitations or management practices if they are identified as a source of groundwater contamination, within a designated wellhead protection area, or located near public water systems.

In California, agriculture makes a significant contribution to the degradation of both surface and groundwater. Some 70% of the rivers and streams assessed in California, as well as 81% of lakes, and 89% of estuaries, either only partially support, or do not support, aquatic life (US EPA 1998a). The main threat to water quality from AFOs is from dairies, two-thirds of which are concentrated in Central Valley. The Central Valley Regional Board estimates that about 60% of the dairies in its region are not in compliance (Clean Water Network and National Resources Defence Council 1998). However dairy farming, being the largest agricultural industry in California has strong political power, and dairies in Central Valley are ten times larger than the national average. With this strong position, dairies have been successful in delaying stringent regulations. Nevertheless, California has now imposed relatively strict standards on its dairies. One such policy is to stipulate that solid and liquid wastes must be treated separately. Solids must be hauled away from the densely populated Central Valley and the application rate of liquid manure is restricted within the Valley. While in the past there may not have been routine inspections of operations, 1998 saw the start of a crackdown on non-compliant dairies with the imposition of fines and even gaol sentences.

4.4.2 Compliance costs

Analysing the cost burden of water quality standards on agriculture in the US is difficult. The task is vast, and is complicated by the fact that regional legislation varies from state to state because of differences in climate, soil types and the importance of the issue within that region. Estimates of costs are given for some regions only.

Due to size and location, Californian dairy farms have the lowest production costs in the US. Limited prolonged storm water volumes, and absence of frozen ground, which suspends waste applications, is likely to mean that California's compliance costs may also be the lowest. Potential compliance costs (using retention pond and irrigation option) are estimated as between 2% and 12.4% of the total economic costs of Californian dairies (Heimlich *et al* 1998).

The study by Leatham *et al* (1992) on the impact of Texas water quality laws made some interesting findings. Increases in annual operating and overhead costs associated with improved waste management were 2.8% of total production costs for small dairies (300 cow herd) and 4.1% for large dairies (720 cow herd). Adding annual charges for investments in machinery and facilities increased total costs by 19.2% and 14.3% for the small and large farms respectively. This indicated that after meeting compliance costs, small dairies were estimated to be insolvent, and the net returns for large dairies fell by 14%.

Heimlich and Barnard's 1995 study estimated the cost of implementing waste management regimes in dairies in order that they could comply with the standards set by the CZARA[45] on the West Coast, the Gulf Coast, the Great Lakes, and the Northeast. As a percentage of cash operating expenses, compliance cost varied from 3% for dairies in the Northeast and large dairies on the southeastern coast, to 18% for

[45] The 1990 amendments to the Coastal Zone Management Act, known as the Coastal Zone Act Re-authorisation Amendments, specifically charged the states to address non-point source pollution affecting coastal water quality.

dairies on the Gulf Coast. Large dairies in the West may have compliance costs of 12.6-18.1% of total economic costs and small dairies as little as 0.08-2.8% of total economic costs. Their estimate is that 80% of farms had compliance costs at less than 10% of their total costs, but it must be noted that CZARA is not as strict as some state standards[46].

4.4.3 Federal assistance

In the US the Environmental Quality Incentives Program (EQIP), offers financial assistance to farmers for environmental purposes. Initially EQIP made available $200 US million annually, but this was reduced to $174 US million for 1998. In 1997 and 1998, approximately 54% of this funding is given to farmers for addressing animal waste problems. CAFOs cannot use EQIP money to build animal-waste storage or treatment facilities but can use it to manage and apply manure. Farmers are eligible to receive at most $10,000 per year and a maximum of $50,000 (NASDA 1998). In the US the provisional figure for the 1998 PSE for milk production is 61%, and for environmental costs the PSE is 0 – 75%.

4.5 Conclusions

Motivated by similar concerns, environmental standards among western nations do not differ significantly. In terms of water quality, New Zealand, the EU, Australia, and the US all maintain that "water for drinking should be free of disease-causing micro-organisms, harmful chemicals, objectionable taste and odour problems, and excessive levels of colour and suspended material" (Maher *et al* 1997, 5). Furthermore, allowable levels of nitrate in drinking water vary little across the four regions, though some countries have extended the application of their limit to all water sources. Differences however, do lie in potential compliance costs, and in how these costs are distributed between the polluters and the rest of society. Compliance cost differences are due primarily to climatic conditions, intensity of farming, farming practices, and also the methods used to meet the water quality standards. Finally, compared with New Zealand, it is also clear that there are significant differences in the level of assistance enjoyed by the dairy sector of each of these

[46] Texas and Florida have strict state standards.

three regions both for dairy production as a whole, and specifically in meeting environmental regulations.

Chapter Five

Trade Impacts of Water Quality Regulations: Methodology

5.1 Introduction

The second objective of this study is to look at the impact of environmental policy measures, that affect the dairy sector, on the competitiveness of New Zealand dairy producers in the world market. Abbott and Bredahl (1993, 12) define competitiveness as "the ability to deliver a product at the appropriate time to the appropriate place in the form demanded by customers and consumers at a comparable price, while at least earning opportunity costs on factors of production". As far as the New Zealand dairy producer is concerned, compliance with environmental regulations increases the cost of production. The question is whether this increase is significant enough to affect the quantity of milk (and subsequently dairy products) produced, and the overall value of exports of New Zealand dairy products. To analyse this question, an applied general equilibrium (AGE) approach has been taken.

Earlier empirical studies investigating the implications for trade of environmental regulations have been primarily in the industrial sector. Several have used a multi-country econometric analysis employing the "Heckscher-Ohlin-Vanek" (HOV) model (Tobey 1990, 1993). Another analysed cross-country data using a trade flow equation, that takes into account bilateral trade flows (van Beers and van den Bergh 1997). One study used econometric methods to test the hypothesis that environmental stringency leads to loss of international competitiveness in manufactured exports by using a dummy variable to represent environmental stringency (Ratanayake 1996). Perroni and Wigle (1997) link a computable general equilibrium (CGE) model with a Generalised Algebraic Modelling System (GAMS) programme to do some environmental policy modelling. They investigate the enforcement of a set of emissions fees aimed at reducing the damage done by industrial pollution by setting environmental taxes at their economically appropriate level. Their work is purely illustrative, but does show "how a CGE model without abatement or environmental benefits can be used to achieve better representation of the consequences of environmental policy" (Perroni and Wigle 1997, 306).

Similar studies involving the agricultural sector are more difficult to conduct. Non-point source environmental damage is harder to measure, which makes monitoring and enforcement of environmental policies in this sector more difficult than in the industrial sector. In some studies, estimates have been made of the cost of environmental compliance within individual sections of the agricultural sector. Some have been in terms of estimated crop loss due to the removal of pesticides and inorganic fertiliser (Zilberman *et al* 1991; Babcock, Lichtenberg and Zilberman 1992; Frandsen and Jacobsen 1999). Others looked at the cost involved in changing production methods, waste disposal systems, or reduction in the intensity of farming practices (Leuck and Haley 1996; Boggess, Johns and Meline 1997; Brouwer *et al* 1999). Komen and Peerlings (1996) use an AGE model for the Netherlands to look at the nation-wide effect on agriculture of the Dutch 1996 energy tax. Leuck *et al* (1995) use a static partial equilibrium model of world agricultural trade to analyse the effect of two different policies within the EU to reduce nitrates in the soil as compared with a hypothetical fertiliser tax.

In this research an AGE approach has been chosen to examine any possible loss of competitiveness brought about by increased environmental costs in the agricultural sector. Analysis is restricted to the control of effluent in the New Zealand dairy sector. The reason for choosing an AGE approach is that by using a well-documented CGE model "it can help focus discussion on the economics of the analysis, rather than the mechanics of model formulation and solution" (Perroni and Wigle 1997, 337). An estimate has been made of the additional production costs for the New Zealand dairy sector in order to comply with water quality regulations. For the second objective of this research, the aim is to use a 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 results will also shed light on the effect of an increase in the cost of production in New Zealand's main exporting sector, on the reallocation of resources to other sectors, and on possible effects on welfare.

Ferrantino (1997), for example, makes an interesting suggestion in his study, which could have been verified, had he used a CGE model. He looks at the pollution abatement costs of the manufacturing sectors of both the US and a group of developing countries. He notes that capital expenditure for abatement was as high as 10.7 per cent of total capital expenditure for the US manufacturing sector in 1992. Ferrantino goes on to suggest that the main effect of US environmental regulation on competitive advantage may be "through the diversion of capital from production activities rather than through higher product prices. Since environmental equipment investments are primarily purchased from the industrial machinery sector, this in turn suggests that some of the capacity of that sector is being diverted from production (both domestically and for export) and towards domestic pollution control activities" (Ferrantino 1997, 50).

The CGE model used in this study is the Global Trade Analysis Project (GTAP). GTAP makes use of comprehensive data on international industry and policy to investigate market (in particular, trade) consequences of environmental policy. On the down side the GTAP model does not incorporate environmental externalities. Perroni and Wigle (1997, 338-9) point out that "Implicit in models without environmental benefits is the assumption that environmental feedback to the economy (particularly through preferences and utility) are separable from those market transactions forming the core of the model. ...however such models may miss some types of interactions:

1. Changes in the relative valuation of the public good compared to private goods.
2. Changes in the relative prices of goods occasioned by the shift of consumption shares and by the resulting shifts in intermediate use...
3. Interactions between abatement activities taken by firms and private mitigating expenditures such as buying water purifiers"

This is the case here. The model to be used in this study, does not measure the benefit to society of cleaner surface and ground water. Neither does it measure the cost of individuals having to purify their own water in the absence of these environmental policy measures.

5.2 The Global Trade Analysis Project (GTAP)

5.2.1 Introduction to GTAP

GTAP is a computable general equilibrium model of global trade. It is a relatively standard, multi-region model that is used by researchers world-wide. This analysis uses Version 4 of the GTAP database, in which the complete model divides the world economy up into 50 sectors (20 of which are agricultural or processed foods) and 45 countries or country groups. The 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. There are five endowment commodities, these being land, unskilled labour, skilled labour, capital and natural resources.

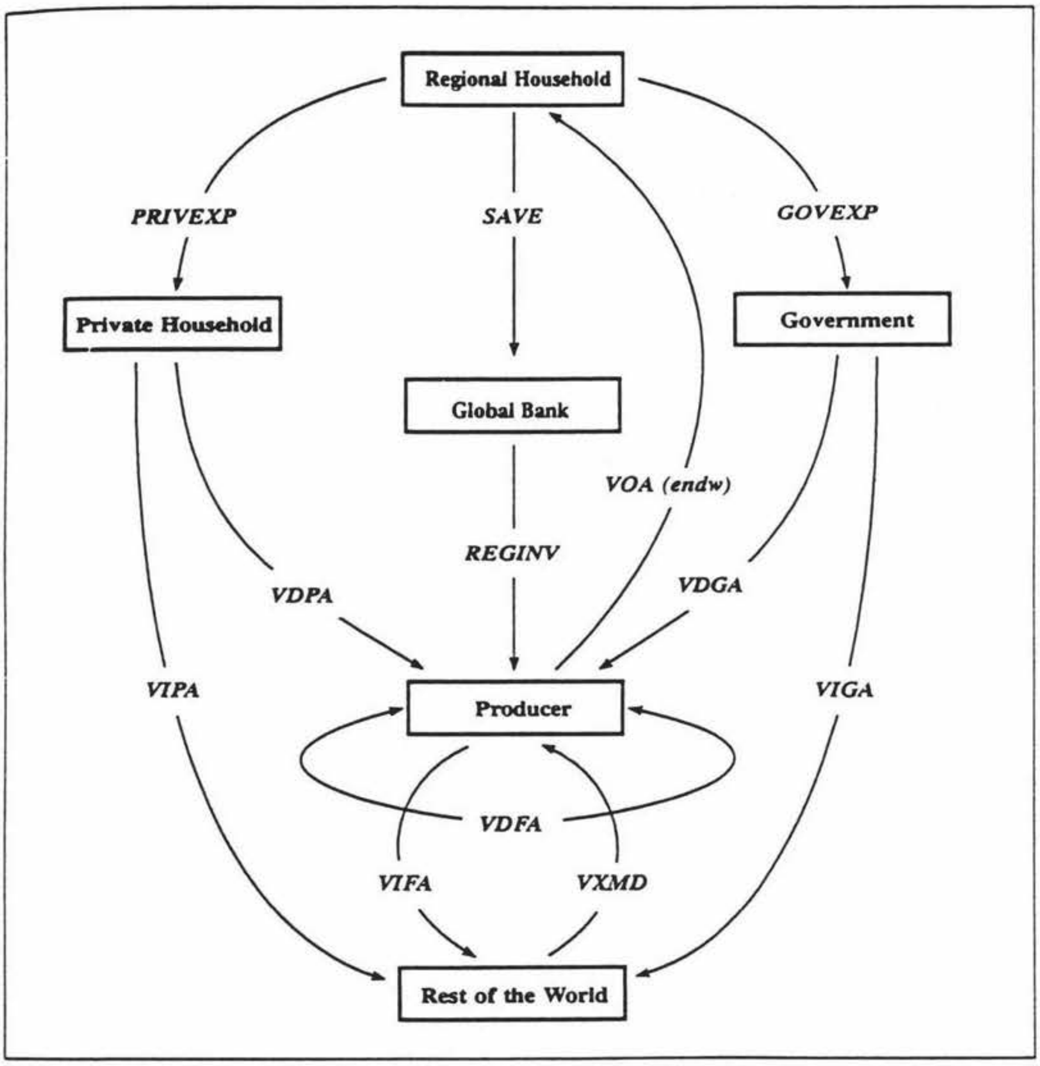
A large amount of notation is required in order to clearly specify all information in the database. A glossary of the relevant GTAP notation can be found in Appendix 4, Table A4.1. Before beginning the next section, distinction must be made between the use of upper and lowercase notation. Sets and parameters are given in uppercase. Database variables are also denoted in uppercase. Percentage changes in these variables are written in lower case.

5.2.2 Overall structure of the GTAP model

Figure 5.1 provides an overview of the structure of the GTAP model. Within each region's domestic economy, the model links government, households, and firms. Then in order to include international trade it adds a further region, *Rest of the World (ROW)* and two global sectors (the Global Bank shown, and the International Trade and Transport Activity sector not shown in Figure 5.1).

Within the domestic economy, the regional household (at the top of Figure 5.1) has its expenditure determined by an aggregated utility function. This study assumes a Cobb-Douglas utility function, which dictates constant budget shares across the three broad categories of private, government, and savings expenditures. This means that a rise in income leads to an increase in private consumption, savings and government expenditure. A clear advantage in this assumption is the unambiguous change in

Figure 5.1: Structure of GTAP



PRIVEXP(r)	private household expenditure in region *r* evaluated at agents' prices
SAVE(r)	value of net savings in region *r*
GOVEXP(r)	government household expenditure in region *r* evaluated at agents' prices
REGINV(r)	gross investment in region r that equals value of output of sector "cgds"
VOA (endw)	value of output at agents' prices of endowment commodities
VDPA(i,r)	value of expenditure on domestic tradeable commodity *i* by private household in region *r* evaluated at agents' prices
VDGA	value of expenditure on domestic tradeable commodity *i* by government household in region *r* evaluated at agents' prices
VIPA*(i,r)*	value of expenditure on imported tradeable commodity *i* by private household in region *r* evaluated at agents' prices
VIGA*(i,r)*	value of expenditure on imported tradeable commodity *i* by government household in region *r* evaluated at agents' prices
VDFA*(i,j,r)*	value of purchases of domestic tradeable commodity *i* by firms in sector *j* of region *r* evaluated at agents' prices
VIFA*(i,j,r)*	value of purchases of imported tradeable commodity *i* by firms in sector *j* of region *r* evaluated at agents' prices
VXMD*(i,r,s)*	value of exports of tradeable commodity *i* from source *r* to destination s evaluated at (exporter's) market prices

Source: Hertel and Tsigas 1997

welfare. However, a disadvantage is that government spending is not linked to tax revenues. Therefore, in the model a reduction in taxes does not mean a decrease in government spending. The omission of the link between government expenditure and tax revenues is unavoidable since the GTAP data does not have complete information on the tax instruments of all regions (Hertel and Tsigas 1997).

Without taxes, household income is derived from the "sale" of endowment commodities to firms (represented by *VOA (endw))*. To produce final goods, firms combine these endowments with intermediate goods *(VDFA)*. This involves sales to private households *(VDPA)* and to government *(VDGA)*. It also includes the sale of investment goods to meet the demand for savings *(REGINV)* by the regional household.

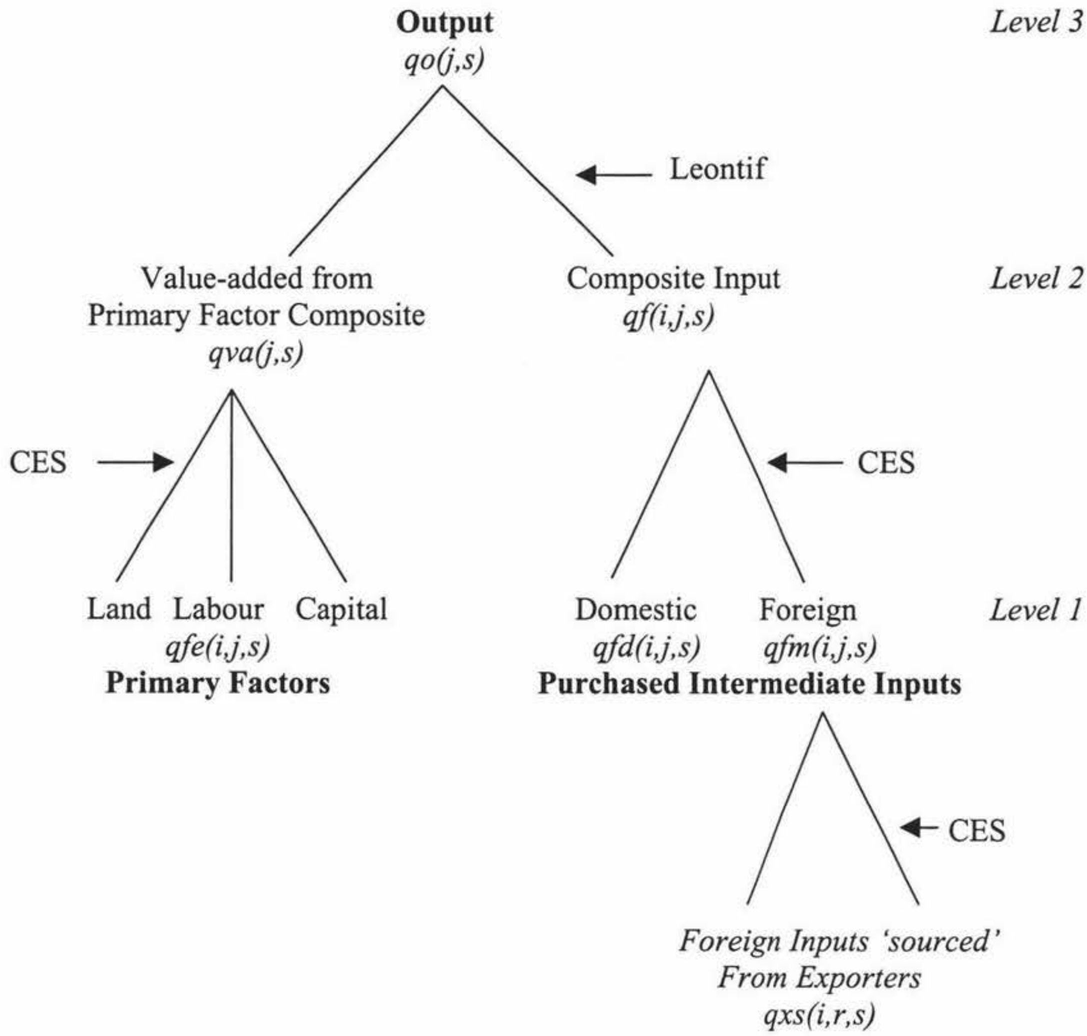
The region, *Rest of the World (ROW)* has an identical structure to that of each domestic economy. In terms of international trade, the domestic economy both imports from and exports *(VXMD)* to the *ROW*. Imports are traced directly to government, households, and firms within the domestic economy. This means direct import payments to *ROW* can be isolated as being from private households *(VIPA)*, government households *(VIGA)*, and firms *(VIFA)*. This innovation to a global trade model "is especially important for the analysis of trade policy in regions where import intensities for the same commodity vary widely across uses" (Hertel and Tsigas 1997, 16).

The first of the two global sectors is the *Global Bank* (Figure 5.1), which is the intermediary between global savings and regional investment. It "assembles a portfolio of regional investment goods, and sells shares in this portfolio to regional households in order to satisfy their demand for savings" (Hertel and Tsigas 1997, 16). The second global sector (not shown in Figure 5.1) chronicles international trade and transport activity.

5.2.3 GTAP's production structure

The focus of this study is on production and changes to the cost of production. Figure 5.2 shows the assumed technology for firms in each of the industries in the model. The lower level of a firm's production 'tree' (level 1) shows the individual

Figure 5.2: Production Structure



where variables (in percentage change form) are:

qo(j,s) quantity of output of non-saving commodity *j*, in region *s*

qva(j,s) quantity index of value-added (eg. land labour composite) in firms of sector *j* in region *r*

qf(i,j,s) quantity of composite tradeable commodity *i* demanded by firms of sector *j* in region *r*

qfe(i,j,s) quantity of endowment commodity *i* demanded by firms in sector *j* of region *s*

qfd(i,j,s quantity of domestic tradeable commodity *i* demanded by firms in sector *j* of region *s*

qfm(i,j,s) quantity of imported tradeable commodity *i* demanded by firms in sector *j* of region *s*

qxs(i,r,s) quantity of exports of tradeable commodity *i* from source *r* to destination *s*

Source: Hertel and Tsigas 1997

inputs demanded by the firm. In the left-hand 'nest' are the primary factors of production. These are land, labour (skilled and unskilled) and capital. Their quantities, in percentage change form are denoted *qfe(i,j,s)*. When utilised and combined these give the 'value-added' component from the primary factor composite (level 2).

In the right-hand nest (level 1) are the intermediate inputs purchased by the firm. Some of these are produced domestically and some are imported. The foreign inputs come from exporters, shown in the very lowest nest of branches of the tree. The purchased intermediate inputs are combined at the next level up (level 2) and are expressed as a composite input.

Finally, combining inputs from both sides of the tree at level 2 produces the total output at the top of the production tree (level 3).

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. The model also assumes constant returns to scale. Therefore this leaves only the relative prices of land, labour, and capital as arguments in the firms' conditional demand equations for components of value-added. Furthermore, this separability is symmetric, meaning that the combination of intermediate inputs is also independent of the prices of primary factors (Hertel and Tsigas 1997).

A further assumption of the model is that one primary factor cannot be replaced by two or more primary factors. It must be substituted for by only one replacement primary factor. "This CES assumption is quite general in those sectors that employ only two inputs, capital and labour. However, in agriculture where a third input, land, enters the production function, we are forced to assume that all pairwise elasticities of substitution are equal. This is surely not true, but we do not have enough information to calibrate a more general specification at this point" (Hertel and Tsigas 1997, 40). 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"[47] 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. "This assumption is necessary to take into account two-way trade while an unrealistically high degree of specialisation is avoided" (Komen and Peerlings 1996). Thus a firm's initial decision is from where will they source their imports. With this decision made, the composite import price can be determined and the preferred mix of domestic and imported goods chosen. The imported and domestically produced commodities are aggregated into a new composite commodity using constant returns to scale, CES functions.

The equations describing the behaviour of firms in the production structure are given in Tables A4.2 and A4.3 in Appendix 4. Each group of equations refers to one of the "nests" or branches in the tree diagram of the production structure in Figure 5.2. There are two types of equations for each nest. The first is a set of conditional demand equations, which are an expression of the substitution among the inputs within that nest. The second is a composite price equation from which is calculated the unit cost of the good produced by that branch. The composite price is then substituted into the nest above, to be used to ascertain the demand for this next composite.

Of particular interest in this investigation are the equations describing both the value-added nest, and the total output nest on the technology tree (Table A4.3 in Appendix 4). Looking firstly at the value-added nest, equation *(6)* describes the changes in the price of the value-added from the primary factor composite:

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

$$(6) \quad pva(j,r) = \sum_{i \in ENDW} SVA(i,j,r) * [pfe(i,j,r) - afe(i,j,r)] \qquad \forall j \in PROD, \; \forall r \in REG$$

where:

pva(j,r) change in the price of value-added in sector *j* of region *r*

SVA(i,j,r) the share of endowment commodity *i* in value-added of firms in sector *j* of region *r* evaluated at agents' prices.

pfe(i,j,r) change in the demand price of endowment commodity *i* for firms in sector *j* of region *r*

afe(i,j,r) change in the primary factor *i* augmenting technical change in sector *j* of region *r*

This equation shows how a change in at least one of three variables affects the value-added price from the primary factor composite. These three variables are, the demand price of the endowment commodity, its share in production of the output, and the rate of the primary factor-augmenting technical change.

Equation *(7)* explains changes in the conditional demands for endowment commodities *(qfe)* in each sector:

$$(7) \quad qfe(i,j,r) + afe(i,j,r) = qva(j,r) - \sigma_{VA}(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)] \qquad \forall i \in ENDW, \; \forall j \in PROD, \; \forall r \in REG$$

where:

qfe(i,j,r) change in the quantity of endowment commodity *i* demanded by firms in sector *j* in region *r*

afe(i,j,r) change in the primary factor *i* augmenting technical change in sector *j* of region *r*

qva(j,r) change in the quantity index of value-added (primary factor composite) for firms in sector *j* in region *r*

$\sigma_{VA}(j)$ elasticity of substitution between the value-adding primary factors for firms in sector *j*

pfe(i,j,r) change in the demand price of endowment commodity *i* for firms in sector *j* of region *r*

pva(j,r) change in the price of value-added in sector *j* of region *r*

In this research the focus is on technical change. *AFE* is a primary factor-augmenting technical change variable, where *AFE(i,j,r)* * *QFE (i,j,r)* equals the effective input of primary factor *i* in sector *j* of region *r*. If there is a positive primary factor-augmenting technical change, (*afe(i,j,r)* > 0), then there is a fall in the effective price of primary factor *i*, which is why it is subtracted from *pfe* in both equations *(6)* and *(7)*. The effect will be three-fold. Firstly, there will be some substitution of factor i for other primary inputs via the right-hand side of equation *(7)*. Secondly, the increased productivity of primary factor i will also result in some reduction in demand (at constant effective prices) for i via the left-hand side of equation *(7)*. Thirdly, equation *(6)* shows that the positive primary factor-augmenting technical change lowers the cost of the value-added composite, encouraging expansion in the use of all primary factors (Hertel and Tsigas 1997).

The total output nest (the top nest in Figure 5.2) gives rise to the demand for composite value-added and intermediate inputs. With the assumption of no substitutability between intermediates and value-added, the relative price component of these conditional demands drops out, leaving only the expansion effect. Three types of technical change are introduced in this nest, but the one of interest in this study is $ao(j,r)$ which is a Hicks-neutral, output-augmenting technical change in sector j of region r. With this technical change, the input requirements for producing a given level of output are uniformly reduced. The relevant equation here is:

(8) $$qva(j,r) + ava(j,r) = qo(j,r) - ao(j,r) \qquad \forall j \in PROD \quad \forall r \in REG$$

where:

$qva(j,r)$	change in the quantity index of value-added in firms of sector j in region r
$ava(j,r)$	change in the value-added augmenting technical change in sector j of region r
$qo(j,r)$	change in the quantity of output of non-saving commodity j, in region r
$ao(j,r)$	change in the output augmenting technical change in sector j of region r

Equation *(8)* shows that a positive output-augmenting technical change ($ao(j,r) > 0$) clearly increases the quantity of output. This is also the case for a positive value-added augmenting technical change.

This study holds with the zero pure profit assumption, so that payments received by firms are totally consumed by costs. Equation *(10)* (Table A4.3 in Appendix 4) restates the zero profit condition, which is used to calculate the price of the output. It shows the effect of technical change on the composite output price.

5.2.4 Exogenous variables

For this study a number of variables in the model are made exogenous. These are the population of each region (*POP*), the quantity of endowment commodities in each region (*QO(ENDW_COMM,REG)*), and the price of a composite capital good supplied to savers by the global bank (*PSAVE*)[48]. All the technical change variables are also exogenous. These include output augmenting (*AO*), primary factor augmenting (*AFE*), composite intermediate input augmenting (*AF*), and value-added augmenting (*AVA)* technical change. Technical change in the transportation of tradable commodities (*ATR*) is also exogenous, as are a number of policy variables including tax on output (*TO*), exports (*TXS*) and imports (*TMS*), and variable export tax on exports (*TX*) and variable import tax on imports (*TM*).

5.2.5 Aggregations

For the purpose of this study, the GTAP database has been aggregated to ten regions. These are New Zealand and her main competitors in the arena of dairy trade, Australia, the European Union (EU), the US and Canada. Also identified are Northeast Asia, Southeast Asia, Russia and Central America, which are identified as the major importers of New Zealand's dairy products. The commodity aggregation also separated the database into ten commodity groupings. The agricultural sector is modelled as milk, other livestock, wool, grains, other crops, dairy products, meats, other processed food, forestry and the remaining commodities, which are grouped as manufacturing and services. For a detailed summary of the aggregations, see Table A4.4 in Appendix 4.

5.3 Experiments

5.3.1 Experiment One

In Chapter Three the cost to the New Zealand dairy sector of compliance with standards for surface and ground water quality is estimated. This estimate lies between 2.0% and 3.2% of the dairy farmers' total costs.

Regulations pertaining to water quality have required dairy farms to adopt a land-based disposal system for dairy shed effluent. The adoption of such systems impacts

[48] This forces global savings to equal global investment.

primarily on a dairy farmer's capital and unskilled labour costs (this is detailed in Chapter Three). For this reason the cost of compliance with environmental policy standards was disaggragated into these two components. The percentage of a dairy farm's total capital cost attributable to environmental compliance lies between 3.2% and 3.6%, and between 19.4% and 19.5% for their total unskilled labour costs.

As the GTAP data base (version 4) 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 (refer to Chapter Three). 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. If the milk production sector continues 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 change). This would require $afe(i,j,r) < 0$, 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 change, and the other an unskilled labour-augmenting change. Upper bound figures will be used to represent a worst case scenario, and the *afe* shocks will need to be negative. The two shocks, then, will be:

afe(capital, milk, NZ) = -1.8

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

The changes will come through equations *(6)* and *(7)* in the value-added nest (given earlier in this chapter). Here equation *(6)* is:

$$(6) \quad pva(milk,NZ) = \sum_{i \in ENDW} SVA(i, milk, NZ) * [pfe(i,milk,NZ) - afe((i,milk,NZ)]$$

Therefore by subtracting a negative capital-augmenting technical change in the milk sector, we effectively increase the demand price for capital (*pfe*). This is then weighted according to capital's share in the cost of milk production (*SVA*). The same is done for the negative unskilled labour-augmenting technical change. Finally the two are added to give the increase in the price of the value-added component (from the primary factor composite) in New Zealand's milk production sector (*pva*).

Secondly, equation *(7)*:

$$(7) \quad qfe(i,milk,NZ) + afe(i,milk,NZ) = qva(milk,NZ) - \sigma_{VA}(milk) * [pfe(i,milk,NZ) - afe(i,milk,NZ) - pva(milk,NZ)]$$

where $i \in$ {capital, unskilled labour}

On the left-hand side of the equation the negative capital-augmenting technical change reduces the New Zealand milk sector's demand for capital *(qfe)*. On the right-hand side the demand price for capital *(pfe)* in milk production less the price of value-added in the milk sector is increased with the subtraction of the negative capital-augmenting technical change. This is multiplied by the elasticity of substitution between the value-adding primary factors for milk (σ_{VA}) and all this is subtracted from the quantity index of value-added *(qva)* in New Zealand's milk producing sector. The same is done to calculate the effect of the unskilled labour-augmenting technical change in the milk sector.

Experiment one shocks only the New Zealand milk-producing sector leaving this sector in the other countries unchanged. This allows us to see the effect on the New Zealand dairy sector if compliance to water quality standards was enforced in New Zealand but not in the other regions.

5.3.2 Experiment Two

Each of the principal dairy exporting countries has environmental standards or regulations in place that address the issue of water quality. These vary in stringency and the degree to which they are enforced differs from country to country and even for regions within countries. Experiment Two assumes that for the standards in place, compliance is enforced for each of the four main regions under investigation – New Zealand, the EU, Australia, and the US.

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

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. Furthermore, each of these regions has a dairy sector that receives a significant level of economic assistance from the government (Chapter Four details this). This means that the additional production costs to the farmer are not as great as they would have been without government subsidies. With less of an 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, the model 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.

Regarding the US milk-producing sector, use is made of the estimated potential compliance costs as a percentage of the dairy farm's total cost. In the US, compliance cost estimates vary between states and with herd size (see Chapter Four). Note has been taken 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 data 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 which will be half the upper bound compliance cost. This will mean a negative shock to variable *AO*, so that the input requirements for producing a given level of output are uniformly increased. The shock used is:

ao(milk, USA) = -5

The relevant equation is equation *(8)* (also in Table A4.3 in Appendix 4) in the total output nest:

(8) $qva(milk, US) + ava(milk, US) = qo(milk, US) - ao(milk, US)$

where:

qva(milk, US)	change in the quantity index of value-added in the milk sector of the US
ava(milk, US)	change in the value-added augmenting technical change in the milk sector of the US
qo(milk, US)	change in the quantity of milk output in the US
ao(milk, US)	change in output-augmenting technical change in the milk sector of the US

The value-added augmenting technical change variable (*ava*) is held constant. Therefore for dairy farms in the US, a negative output-augmenting technical change will reduce the total milk output.

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 estimate of the cost to the farmer of meeting the standards outlined in the Nitrate Directive of 1991 for the EU. Without this cost estimate, an *ao* shock was unable to be implemented for the EU's milk production sector, as was carried out for the US. It was however 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%[49]. Experiment Two uses their

[49] The Nitrate Directive impacts not only on dairy production, but on all livestock production and cropping. To achieve the nitrogen MAR, output of all livestock will decrease (the extent will depend

result, halving its magnitude. 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*. The shock used is:

qo(milk, EU) = -3.9.

To this point *QO* for produced commodities has been 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%. The changes come through equation *(8)* as shown above for the US.

Australia, on the other hand 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. These were estimated to lie between 2% and 3.2% of the dairy farm's total cost. The upper bound will be used as an estimate of compliance costs for Australia. Therefore the final shock for Experiment 2 will be a negative, output-augmenting technical change shock to Australia's milk production sector half the size of the compliance cost estimate. Again the changes come through equation *(8)* using the shock:

ao (milk, Australia) = -1.6.

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

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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.

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.

Chapter Six

Trade Impacts of Water Quality Regulations: Results and Discussion

6.1 Experiment One

Experiment One shocks only the New Zealand milk-producing sector, leaving this sector unchanged in the other countries. This shock proxies the increase in primary factor costs incurred after 1995, which would result if all dairy farms yet to comply with land-based effluent disposal were required to do so (refer to Chapter Five for details).

The negative capital-augmenting and unskilled labour-augmenting technical change shocks result in a 3.3% drop in total milk production and a decrease of 4.6% in the quantity of dairy products produced in New Zealand (Table 6.1). There is little measurable change in production in the other sectors.

Table 6.1 Effect on the Volume of Output and the Supply Price of Commodities in New Zealand (% change) - *Experiment One*

Commodity:	Output (*qo*)	Supply price (*ps*)
Milk	-3.3	3.2
Dairy products	-4.6	1.6
Other crops	0.1	-0.1
Grains	-0.3	-0.1
Other livestock	-0.2	0.0
Wool	-0.1	-0.1
Forestry	0.1	-0.1
Meats	-0.2	1.0
Other processed food	0.0	-0.1
Manufacturing & Services	0.0	-0.1
Capital Goods commodities	-0.2	-0.1

The negative productivity shock to the dairy sector results in a contraction of the dairy 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% (Table 6.2), 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 all other production sectors, with the exception of forestry. Demand for unskilled labour in the dairy processing sector (Table 6.2) falls by roughly the same amount as the decline in the level of output (Table 6.1).

Table 6.2 Effect on Factor Demand in New Zealand's Milk and Dairy Product Sectors (% change) – *qfe. Experiment One*

Factor of Production	Milk	Dairy Products
Land	-0.9	0
Unskilled Labour	6.1	-4.7
Skilled Labour	-1.8	-4.6
Capital	-0.5	-4.6

The demand for land for milk production falls by almost 1%. There is a small movement of land (less than 1% in each case) into cropping, and other livestock, primarily sheep farming. Since dairy farming is a major user of land in New Zealand, this decrease in demand results in the price of land in most sectors falling by around 3%[50].

Table 6.2 also shows that with the decline in output of both milk and dairy products, there is a decrease in demand for skilled labour and capital in both the milk and dairy processing sectors. However, the change in the price of capital and skilled labour is negligible.

The value of New Zealand's GDP (variable *vgdp*) decreases by one tenth of one percent and household income (variable *y*) falls by one fifth of one percent. This very small drop in income will lead to a correspondingly small decrease in the domestic demand for goods and services. Therefore the decline in volume of output in most sectors is the result of reallocation of some resources into the now less

[50] For dairy farming the price of land falls by almost 4%.

productive milk sector and a small overall reduction in demand for goods and services.

With some of the resources allocated to the milk sector now being used to reduce the negative externality of ground and surface water pollution, the cost of milk production increases. The outcome is a 3.2% increase in the price of milk (variable *ps*) and a 1.6% increase in the overall price of dairy products.

The rise in the price of New Zealand milk and the increase in the world (fob) price of exported New Zealand dairy products[51] (excluding the transport margin) has no measurable effect on the world price index (variable *pw*) for either total supply of milk or dairy products. However, the 1.6% price increase in New Zealand's dairy products leads to a reduction in the overall quantity of exports of New Zealand's dairy products. Table 6.3 shows that dairy exports to Australia fall by almost 5%, by over 5% to Southeast Asia, and by around 6% to all other regions. New Zealand loses market share to her main competitors in her most important dairy markets. Both the EU and the US increase the volume of their dairy exports to Australia by 1.8%, to Southeast Asia by 1.4%, and to Northeast Asia by almost 1%. Australia increases her volume of dairy exports to these regions by a similar amount (Table 6.3).

The overall value of New Zealand's dairy exports[52] (using fob weights) falls by 4.3%, while all other regions experience a small increase in the value of their dairy exports, with Australia's increase being almost 1%.

The quantity index for world supply of dairy products (variable *qow*) and hence the value of the global supply of dairy products (variable *valuew*) remains unchanged.

The effect of this increase in primary factor costs to the New Zealand dairy sector, has only a small impact on the quantity of export sales from other New Zealand sectors. Meats experience a small decrease in quantity of export sales of 0.2% to all

[51] Variable *pfob*
[52] Variable *vxwfob*

Table 6.3 Effect on the Quantity of Export Sales of Dairy Products from the Principal Dairy Exporters (% change) – *qxs*
Experiment One

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 6.4 Effect on the Commodity Trade Balances of the Principal Dairy Exporters ($US million) – *DTBAL*
Experiment One

Exporter:	NZ	Australia	EU	USA
Commodities:				
Dairy Products	-76.4	11.5	39.4	6.0
Other crops	2.3	-1.0	-3.8	0.3
Grains	0.2	-0.3	-0.3	0.7
Other livestock	1.2	-0.5	-0.7	0.0
Wool	1.3	-0.9	-0.1	0.0
Forestry	1.1	0.0	-0.2	-0.4
Meats	-3.0	0.1	1.1	1.0
Other processed food	5.0	-1.2	-2.1	0.2
Manufacturing & Services	82.4	-9.5	-40.8	-11.0
Total Trade Balance	14.1	-1.9	-7.4	-3.3

export destinations whereas all other sectors experience a small increase both in quantity and value of exports.

The effect on the commodity trade balances of each region is given in Table 6.4. The value of New Zealand's dairy exports has fallen by $US76.4 million, but this has been countered by an increase from the manufacturing and services sectors of more than this amount and also small increases in the value of exports from other sectors. Thus there is a positive net effect on New Zealand's trade balance of $US14 million, while all other regions experience a small, negative net effect on their trade balance.

Finally, a look at how these two negative *afe* shocks to New Zealand's main exporting sector might affect welfare (variable *EV*). The experiment indicates a decrease in overall welfare in New Zealand of $US53 million. Since this CGE model does not incorporate environmental externalities, this measure of welfare does not include any welfare gained by improving water quality. However, since society has insisted on an effort to improve ground and surface water quality, it could be assumed that cleaner water does increase welfare. Welfare for each region has moved in the negative direction, so that there has been a decline in welfare world wide of $US164 million. Australia and the EU have experienced a very small expansion in their milk production sectors and increased their export of dairy products. However both of these countries already has a protected dairy sector and therefore a misallocation of resources. Expansion of this protected sector will see an increase in this inefficient use of resources. Resources will be moved out of sectors in which the country may have a comparative advantage into the less efficient dairy sector, hence the decrease in welfare.

6.2 Experiment Two

Experiment Two applies shocks to the four principal dairy exporting regions. Each shock proxies the increased costs incurred by the milk production sector of each region in order to meet the water quality standards set by that 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 each of the major dairy exporting regions experiencing a decline in productivity in their milk sectors, the quantity index for world supply of milk and of dairy products falls by 0.6% and 1.9% respectively. Further, the world price index for milk rises by 14.5% and for dairy products by nearly 9%. With the large increase in both these price indexes, the value of the global supply of milk and dairy products rises by 13.8% and 6.9% respectively.

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%. Thus the EU experiences a price increase for dairy exports at least five times larger than the percentage increases experienced by her competitors. This causes the EU to lose market share to the other principal dairy exporters. Table 6.5 shows the reduction of the EU's dairy exports everywhere by at least 30% and by as much as 38.5% to Northeast Asia.

The price index of global dairy exports (variable *pxwcom*) rises by 13%. In response to this and the decline in dairy exports from the EU, New Zealand increases the volume of dairy exports to all destinations as can be seen in Table 6.5. Furthermore, the value of New Zealand's dairy exports increases by 19%. This is a larger increase than those experienced by the other principal dairy exporters[53]. The volume of dairy exports from New Zealand has increased across the Tasman by 6.6%, by 6% to Southeast Asia, by 13% to the US and by over 57% to the EU (Table 6.5).

New Zealand production of dairy products rises by 12% and milk production increases by 8.3% (Table 6.6)[54]. The combined effect of a reduction in productivity in the milk sector and an increase in output of both milk and dairy products in New Zealand is a shift of resources into these two sectors. Table 6.7 (page 84) shows the magnitude of these shifts in factor demand among the different production sectors. An increase in New Zealand's milk production of 8.3% gives rise to a 6% increase in

[53] For Australia, the value of her dairy exports increases by 16.3%, while for the US it is up by 17.9%.
[54] In Australia total output of milk and dairy products is up by almost 5% while in the US the increase is 0.3%.

Table 6.5 Effect on the Quantity of Export Sales of Dairy Products from the Principal Dairy Exporters (% change) – *qxs* *Experiment Two*

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

Table 6.6 Effect on Volume of Output and the Supply Price of Commodities in New Zealand (% change) - *Experiment Two*

Commodity:	Output (*qo*)	Supply price (*ps*)
Milk	8.3	5.6
Dairy products	12.1	3.2
Other crops	-1.6	1.5
Grains	-0.2	1.4
Other livestock	-0.2	1.3
Wool	-1.2	1.3
Forestry	-0.5	0.1
Meats	-0.7	1.0
Other processed food	-0.3	0.5
Manufacturing & Services	-0.4	0.4
Capital Goods commodities	-0.1	0.3

demand for land to be used for dairy farming (refer to Table 6.7). As a consequence, land prices in New Zealand increase by 14%[55]. There is a large increase in demand for both unskilled and skilled labour and capital in the milk and dairy product sectors. Movement of these resources is largely away from other crops, wool, meats, and the large manufacturing and services sector. As a consequence there is a small decline in output from all the other sectors (see Table 6.6). This leads to a reduction in the volume of New Zealand's exports of all other commodities to all destinations with the exception of several commodities destined for the EU. The percentage decrease in volume of export sales of these commodities is found in Table 6.8.

The effect on the commodity trade balances of the principal dairy exporters is given in Table 6.9. New Zealand's dairy exports show an increase in value of $US337 million. All other sectors show a decline in the value of their exports so that there is only a small positive effect on New Zealand's overall trade balance. Both Australia and the US exhibit an increase in the value of their dairy exports but experience a net negative effect on their trade balances. The EU on the other hand experiences a significant fall in the value of its dairy exports but this is more than compensated for by a large increase in the trade balance for its very large manufacturing and services sectors.

Finally, of interest is the effect of these five simultaneous shocks on the welfare of the different regions. With the significant move of resources into the milk and dairy products sectors, New Zealand registers an improvement in welfare of $US106 million. Australia also shows some improvement in welfare, but all other regions show a decline in overall welfare. The EU experiences a fall in welfare of nearly $US20 billion.

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[55] Land used in milk production has risen in price by 20.8%, while land for other uses shows a price increase of 14%.

Table 6.7 Effect on Factor Demand in some of New Zealand's Production Sectors (% change) – *qfe*
Experiment Two

Commodity:	Milk	Dairy products	Other crops	Wool	Meats	Manufacturing & Services
Factor of production:						
Land	6.0	0.0	-3.4	-3.0	0.0	0.0
Unskilled labour	19.7	11.8	-1.3	-0.9	-0.9	-0.7
Skilled labour	10.8	12.5	-1.2	-0.8	-0.4	-0.1
Capital	12.3	12.3	-1.2	-0.8	-0.5	-0.2

Table 6.8 Effect on New Zealand's Export Sales of the other Commodities – *qxs*
Experiment Two

Destination:	Australia	EU	USA	Canada	NE Asia	SE Asia	Central America	Russia	ROW
Commodity:									
Other crops	-2.5	-1.3	-3.0	-2.8	-3.6	-3.3	-2.8	-2.2	-2.9
Grains	-3.0	0.5	-2.0	-2.7	-3.2	-3.8	-3.6	-2.0	-3.3
Other livestock	-2.1	4.2	-4.1	-4.2	-4.1	-4.1	-4.4	-0.1	-1.8
Wool	-0.8	-2.0	-1.8	-1.7	-2.6	-2.8	-3.3	-2.6	-2.8
Forestry	-0.5	-1.6	-0.7	-0.7	-0.7	-0.8	0.0	0.0	-0.8
Meats	-1.9	0.7	-2.1	-2.3	-2.5	-2.2	-2.3	-1.2	-1.7
Other processed food	-1.1	0.1	-1.5	-1.6	-1.7	-1.3	-1.5	-0.7	-1.2
Manufacturing & Services	-2.0	-2.7	-2.2	-2.2	-2.2	-2.2	-2.2	-2.4	-2.3

Table 6.9 **Effect on the Commodity Trade Balances of the Principal Dairy Exporters ($US million) – *DTBAL Experiment Two***

Exporter:	NZ	Australia	EU	USA
Commodity:				
Dairy Products	337.4	174.8	-1858.0	188.5
Other crops	-13.0	-0.6	-1025.7	67.4
Grains	-1.2	7.8	-147.6	111.5
Other livestock	-1.9	22.6	-442.3	60.5
Wool	-9.2	24.4	-27.0	-1.8
Forestry	-2.8	-0.1	20.9	-0.4
Meats	-3.4	12.5	-246.0	58.4
Other processed food	-15.4	11.9	-907.8	173.0
Manufacturing & Services	-280.4	-367.9	7398.2	-1572.4
Total Trade Balance	10.0	-114.6	2764.7	-915.4

6.3 Sensitivity Analysis – Experiment Two (Sensitivity)

As stated in Chapter Five, the aim of this part of the study is to give a "broad brush" interpretation of the effects of the increased costs to the New Zealand dairy export sector on overall competitiveness against the other principal dairy exporters. Therefore interest is in the direction (more than in the magnitude) of shifts in quantity of output, prices, use of resources, value of dairy export earnings, GDP, and welfare.

Imposing costs of even half of the compliance cost estimates for each of New Zealand's dairy exporting competitors may still be an overestimate of the costs that these dairy farmers face. Regulations may not be fully enforced, and the level of government assistance to the dairy sector of each of these competitors may continue to be substantial. For this reason the model was run again with the same shock to the New Zealand dairy sector, but halving the size of the shocks to the three other regions, used in Experiment Two. The intention here is to see whether there will still be an expansion of the New Zealand milk and dairy processing sectors and increased dairy exports, even if the costs borne by the dairy sector of each of the other principal dairy exporters are in reality, much less than estimated.

With the decline in total milk output in the EU following the shocks, the volume of dairy products falls 3% and the average supply price for dairy products is up 7.8%. Table 6.10 (on the following page) shows a decline in the EU's dairy exports by 15-20% to all destinations. Dairy exports for both Australia and the US have increased to all destinations (see Table 6.10).

Table 6.10 Effect on the Quantity of Export Sales of Dairy Products from the Principal Dairy Exporters (% change) – *qxs* *Experiment Two (Sensitivity)*

Destination:	**NZ**	**Australia**	**EU**	**USA**	**Canada**	**NE Asia**	**SE Asia**	**Central America**	**Russia**	**ROW**
Exporter:										
NZ		1.2	21.3	3.4	-0.8	-1.1	0.8	3.4	3.9	2.3
Australia	6.7		29.1	10.3	6.0	5.5	7.6	10.3	11.1	9.1
EU	-19.1	-18.6		-16.8	-20.0	-20.5	-19.0	-16.7	-15.6	-17.4
USA	5.6	6.7	27.7		4.9	4.4	6.3	9.2	9.1	7.9

Under this scenario, New Zealand's total milk output rises 2.3% and output for the dairy processing sector increases by 3.4% (Table 6.11).

Table 6.11 Changes in the Milk and Dairy Processing Sectors in New Zealand (% change) – *Experiment Two (Sensitivity)*

Commodity:	Milk	Dairy Products
Quantity of output *(qo)*	2.3 (8.3)[1]	3.4 (12.1)
Supply price *(ps)*	4.3 (5.6)	2.4 (3.2)
Demand for Land *(qfe)*	2.5 (6.0)	0.0 (0.0)
Demand for Unskilled labour *(qfe)*	12.6 (19.7)	3.2 (11.8)
Demand for Skilled labour *(qfe)*	4.2 (10.8)	3.6 (12.5)
Demand for Capital *(qfe)*	5.6 (12.3)	3.5 (12.3)

[1]The figures given in parentheses are the percentage changes that occur for each of the commodities under Experiment Two.

Table 6.11 shows that with the expansion of the milk production sector, primary factor demand has increased. Land is moved out of cropping, grains, other livestock, and sheep farming to meet the increased demand for land for dairy farming.

New Zealand's dairy exports to Northeast Asia and Canada have fallen by around 1%, but they have increased to all other destinations (see Table 6.10). New Zealand's dairy export earnings are up 6.8%, giving rise to a small improvement in GDP (up 0.2%) and a positive effect on national welfare which is up by $US21 million.

These results add credence to the direction of the changes taking place in New Zealand's production and resource use, observed in Experiment Two, in which all four principal dairy exporters experience the full cost of the enforcement of the environmental regulations.

6.4 Discussion

Finally of interest are the varying impacts on New Zealand of the different scenarios presented in these two experiments (see Table 6.12).

Table 6.12 Comparison of the Percentage Change[56] of a number of Variables across the two Experiments

Experiment:	Experiment 1	Experiment 2
Variable:		
Milk: NZ quantity output (*qo*)	-3.3	8.3
Milk: NZ supply price (*ps*)	3.2	5.6
Milk: world price index for total supply (*pw*)	0.0	14.5
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 GDP (*vgdp*)	-0.1	0.5
Welfare - $US million (*EV*)	-$53	$106

Experiment 1 is the situation in which only New Zealand has real costs imposed on her 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 dairy products is significantly reduced. Further New Zealand's supply price of both commodities rises by 3.2% and 1.6% respectively. 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 fall in value of her dairy exports of more than 4% which impacts negatively on welfare. However, this could be negated by the positive impact on welfare as a result of improved surface and ground water quality, which is not included in this welfare measure.

By 1995 approximately half of New Zealand dairy farms were complying with the Regional Councils' moves to have land-based disposal of all dairy effluent. The cost incurred by the New Zealand dairy sector to have the remaining dairy farms discharging their effluent to land was estimated at between $NZ19.7 million and $NZ33.9 million (for details refer to Chapter Three). Incorporation of these changes into a CGE model suggest that these additional compliance costs, in the case where New Zealand experiences this unilaterally, do result in a reduction of the volume of dairy exports to all destinations and a decline in the total value of New Zealand's

56 Actual change for the welfare measure.

dairy exports. This indicates a potential loss of competitiveness for New Zealand in the global dairy market.

From 1995 to the end of 1998 the actual situation has been that another 20% of the total number of dairy farms did convert to land-based systems for effluent disposal. In this time neither a decline in volume or in value of New Zealand's dairy exports has been observed. Furthermore we know that 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. Thus it is more realistic to suggest a scenario, like that presented in Experiment Two, where each of the four principal dairy exporting regions have water quality standards imposed that mean real cost to the dairy sector of each region. These costs are particularly high for the EU (refer to Chapter Four), therefore if they must substantially reduce the number of dairy livestock, then output of milk and dairy products will also be reduced. The model predicts that supply prices of milk and dairy products in the EU will rise substantially. These increases, together with the smaller price rises of milk and dairy products in New Zealand, Australia and the US result in 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%.

New Zealand, with a much smaller supply price rise for both milk and dairy products than in the world market, becomes relatively better off. Volume of milk and dairy product output rises by 8% and 12% respectively and the value of New Zealand dairy exports increases by 19%. New Zealand GDP and household income rises and there is a positive effect on welfare, quite apart from the improvement in welfare brought about by improved water quality.

As all four regions move to fully achieve the standards they have in place, some milk production (from the EU in particular) is likely to move to regions like New Zealand and Australia that have an environmental competitive advantage.

Chapter Seven

Conclusion

7.1 Introduction

The aim of this study was to investigate the impact of current regulations regarding surface and ground water quality on the New Zealand dairy sector. In the introduction two clear research objectives were stated. In this concluding chapter the results relating to these objectives, as well as the shortcomings of the research are discussed. Recommendations for further research are also made.

7.2 Compliance Costs

The first objective of this thesis was to estimate the additional production costs required to comply with the regulations, both at the farm level and at the sector level. In response to the RMA 1991, Regional Councils throughout New Zealand have required dairy farmers to put land-based disposal systems in place for their dairy shed effluent. The analysis included the costs of 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 pasture two or three times a year. The cost to the dairy farmer of implementing a land-based effluent disposal system is estimated to be between 2% and 3.2% of the farmer's total cost. Therefore the total cost of compliance to the New Zealand dairy sector to meet the water quality standards lies between $NZ39.4 million and $NZ67.8 million. In 1995 approximately 50% of dairy farms were operating land-based effluent disposal systems and by the beginning of 1999 this had increased to 70%.

7.3 Trade Impacts of these Compliance Costs

The second main objective of this thesis was to look at the impact of this increased cost of production on the competitiveness of the New Zealand dairy sector in the international market. The objectives were achieved using a general equilibrium approach, and analysing two scenarios. In the first scenario, environmental regulatory enforcement was assumed to be a unilateral decision by New Zealand. Therefore only costs to the New Zealand dairy sector (the result of enforcement of water quality regulations) were increased. This resulted in a reduction in the volume of output for both milk and processed dairy products. New Zealand's supply price for milk and processed dairy products rose, but did not impact on the world price indices of these commodities. Consequently New Zealand experienced a decline in the volume of dairy exports to all destinations, a fall in the value of her dairy exports and a negative impact on welfare. The indication here is a loss of competitiveness for New Zealand in the global dairy market.

For the second scenario, information was gathered regarding water quality regulations in the other three principal dairy exporting regions (the EU, Australia, and the US). Environmental protection in western nations is moving in a similar direction, and allowable levels of nitrate in drinking water for example, vary little across the four regions in question. Differences however, do lie in potential compliance costs (due to climatic conditions and farming practices), and in how these costs are distributed between the polluters and the rest of society. The second analysis was carried out based on some assumptions regarding the level of enforcement of the regulations and also internalisation of costs in the EU, Australia, and the US. In this scenario, each of the four principal dairy exporting regions have water quality standards imposed that mean additional production costs to their dairy sector. Increased costs of production in all four regions resulted in a rise in the global dairy export price index; a rise that was substantially higher than the rise in the supply price of New Zealand processed dairy products. As a result New Zealand increased her share of the dairy export market. To achieve this, output of milk and processed dairy products rose, as did the value of New Zealand dairy exports. These results were tested using two alternative estimates of compliance costs for the EU, Australia, and the US. Furthermore, New Zealand GDP and household income increased, positively affecting welfare, quite apart from the unmeasured improvement in welfare brought about by improved water quality.

Therefore, in conclusion, if only New Zealand were to fully enforce compliance with the water regulations, there would be a loss in international competitiveness for the

New Zealand dairy exporting sector and a change in the pattern of dairy trade across the main dairy exporters. If however, all four principal dairy exporters enforce their water quality regulations and internalise their compliance costs, New Zealand will be better off. The dairy sector is predicted to expand, gaining global market share, and again there will be a realignment of international trading patterns.

The New Zealand dairy sector can be confident that the EU and the US in particular, have well-defined regulations in place and are committed to ensuring their enforcement. Compliance costs for these regions are expected to be higher than those for New Zealand dairy farmers, but so too is the level of government assistance. In the EU some governments of member states will provide grants to farmers where environmental regulations have required significant investment in new capital equipment. This is also the case in the US. Under the GATT Uruguay Round Agriculture Agreement the EU, Australia and the US must make progressive reductions on the subsidies they provide for agricultural production. Since together the EU and Australia have 56% of the dairy export market, as their subsidies are removed world dairy prices will rise which will be very beneficial for New Zealand's dairy sector. On the other hand trade negotiations may give rise to a new category of allowable subsidies. If assistance specifically for environmental protection was excluded from the set of subsidies which must be progressively reduced, then the magnitude of the changes predicted by the model would be altered.

The implication is that as all four regions move to complete achievement of their current water quality standards, and internalisation of the cost of compliance, colder regions may need to concede some dairy farming to more moderate climates. There may be some shift of milk production (from the EU in particular) to regions like New Zealand and Australia that have an environmental competitive advantage.

7.4 Shortcomings of the Research

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[57]. 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.

7.5 Recommendations 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. More detailed research is required on the relative impact of the full bundle of environmental regulations and compliance costs in all major dairy exporting regions.

Also investigation was limited to the impact of water quality regulations on the dairy sector only. These water quality regulations will impact not only on dairy production, but also on all livestock production as well as 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.

[57] These assumptions are detailed in Chapter Five.

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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Appendix 1

Sections of the Resource Management Act, 1991

"The statutory framework for managing water quality and controlling discharges to water is the Resource Management Act, 1991 (RMA 1991). The RMA 1991 is guided in particular by Part II which contains the Purpose (section 5), Matters of national importance (section 6), Other matters (section 7), and Te Tiriti o Waitangi (section 8). Assessment of every resource consent application to do something restricted by the RMA 1991 or by a regional or district plan is subject to Part II" (Manawatu-Wanganui Regional Council 1998).

Relevant Sections of the RMA 1991:

PART II

Purpose and Principles

5. Purpose –

(1) The purpose of this Act is to promote the sustainable management of natural and physical resources.

(2) In this Act, "sustainable management" means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well being and for their health and safety while –

  (a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonable forseeable needs of future generations; and

  (b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and

  (c) Avoiding, remedying, or mitigating any adverse effects on the environment.

6. Matters of national importance –

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall recognise and provide for the following matters of national importance:

(a) The preservation of the natural character of the coastal environment (including the coastal marine area), wetlands, and lakes and rivers and their margins, and the protection of them from inappropriate subdivision, use, and development:

(b) The protection of outstanding natural features and landscapes from inappropriate subdivision, use, and development:

(c) The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna:

(d) The maintenance and enhancement of public access to and along the coastal marine area, lakes, and rivers:

(e) The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga.

7. Other matters –

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall have particular regard to –

(a) Kaitiakitanga:

(b) The efficient use and development of natural and physical resources:

(c) The maintenance and enhancement of amenity values:

(d) Intrinsic values of ecosystems:

(e) Recognition and protection of the heritage value of sites, buildings, places, or areas:

(f) Maintenance and enhancement of the quality of the environment:

(g) Any finite characteristics of natural and physical resources:

(h) The protection of the habitat of trout and salmon.

8. Treaty of Waitangi –

In achieving the purpose of this Act, all persons exercising functions and powers under it, in relation to managing the use, development, and protection of natural and physical resources, shall take into account the principles of the Treaty of Waitangi (te Tiriti o Waitangi).

PART III

Duties and Restrictions under this Act

Discharges

15. Discharge of contaminants into environment –

(1) No person may discharge any –

(a) Contaminant or water into water; or

(b) Contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water; or

(c) Contaminant from any industrial or trade premises into air; or

(d) Contaminant from any industrial or trade premises onto or into land –

unless the discharge is expressly allowed by a rule in a regional plan and in any relevant proposed regional plan, a resource consent, or regulations.

(2) No person may discharge any contaminant into the air, or into or onto land, from –

(a) Any place; or

(b) Any other source, whether moveable or not, -

in a manner that contravenes a rule in a regional plan or proposed regional plan unless the discharge is expressly allowed by a resource consent or allowed by section 20 (certain existing lawful activities allowed).

PART V

Standards, Policy Statements, and Plans

Regional Plans

70. Rules about discharges –

(1) Before a regional council includes in a regional plan a rule that allows as a permitted activity –

(a) A discharge of a contaminant or water into water; or

(b) A discharge of a contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water,-

the regional council shall be satisfied that none of the following effects are likely to arise in the receiving waters, after reasonable mixing, as a result of the discharge of the contaminant (either by itself or in combination with the same, similar, or other contaminants):

(c) The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials:

(d) Any conspicuous change in the colour or visual clarity:

(e) Any emission of objectionable odour:

(f) The rendering of fresh water unsuitable for consumption by farm animals:

(g) Any significant adverse effects on aquatic life.

(2) Before a regional council includes in a regional plan a rule requiring the adoption of the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of any discharge of a contaminant, the regional council shall be satisfied that, having regard to –

(a) The nature of the discharge and the receiving environment; and

(b) Other alternatives, including a rule requiring the observance of minimum standards of quality of the environment,-

the inclusion of that rule in the plan is the most efficient and effective means of preventing or minimising those adverse effects on the environment.

PART IV

Resource Consents

Decisions

107. Restriction on grant of certain discharge permits –

(1) Except as provided in subsection (2), a consent authority shall not grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15 allowing –

(a) The discharge of a contaminant or water into water; or

(b) A discharge of a contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water,-

if, after reasonable mixing, the contaminant or water discharged (either by itself or in combination with the same, similar, or other contaminants or water), is likely to give rise to all or any of the following effects in the receiving waters:

(c) The production of conspicuous oil or grease films, scums or foams, or floatable or suspended materials:

(d) Any conspicuous change in the colour or visual clarity:

(e) Any emission of objectionable odour:

(f) The rendering of fresh water unsuitable for consumption by farm animals:

(g) Any significant adverse effects on aquatic life.

(2) A consent authority may grant a discharge permit or a coastal permit to do something that would otherwise contravene section 15 that may allow any of the effects described in subsection (1) if it is satisfied –

(a) That exceptional circumstances justify the granting of the permit; or

(b) That the discharge is of a temporary nature; or

(c) That the discharge is associated with necessary maintenance work.

(3) In addition to any other conditions imposed under this Act, a discharge permit or coastal permit may include conditions requiring the holder of the permit to undertake such works in such stages throughout the term of the permit as will ensure that upon the expiry of the permit the holder can meet the requirements of subsection (1) and of any relevant regional rules.

Appendix 2

Permitted Activity Conditions for Land-based Discharge of Effluent

The discharge of effluent from dairy premises onto land is a permitted activity provided that the following conditions are met:

(a) There shall be measures in place to ensure that no discharge of effluent to water, that is not part of a treatment system, will occur as a result of pump breakdown or prolonged wet weather.

(b) Any effluent treatment or storage facilities (e.g. sumps or ponds) shall be sealed so as to prevent any contamination of water by seepage of effluent. This shall be done by ensuring that the permeability of the sealing layer does not exceed 10^{-9} metres per second.

(c) Any effluent treatment or disposal systems shall be sited and operated so as to avoid odour and spray drift nuisances.

(d) The effluent loading shall be either:

- at a rate not exceeding 150 kilograms of nitrogen per hectare per year; or
- at a higher rate provided there is no elevation of ground water nitrogen concentrations such that existing or reasonably forseeable uses of the receiving ground water or surface water would be compromised.

(e) The maximum loading rate of effluent onto any part of the irrigable land shall not exceed either:

- 25 millimetres depth per application: or
- a higher rate provided there is no elevation of ground water nitrogen concentrations such that existing or reasonably forseeable uses of the receiving ground water or surface water would be compromised.

(f) Effluent application shall not be undertaken in circumstances such that effluent enters surface water that is not part of a treatment system, or ponds on the land surface for more than 5 hours.

(g) The discharger shall provide information to show how the requirements of the rule [conditions (a) to (f) above] are being met, if requested by Council.

Source: Environment Waikato 1995

Appendix 3

Data and Calculations of Compliance Costs for Water Quality Regulations

Table A3.1 Construction Costs for a basic Travelling Irrigator System

	150 – 249 cow herd	250 – 549 cow herd
Fibreglass sump	$2500	$5500
Motor	$2500	$2500
Pipeline, fittings	$4300	$6300
Hydrants	$700	$1200
Irrigator	$4000	$4000
Labour to install	$2000	$3000
Electrical (wiring/fittings)	$2000	$2000
Total	$18,000	$25,000

Note 1: Costs are based on 1998 estimates from the Waikato Region. Totals are rounded to the nearest thousand.
Note 2: These costs are for a flat to gently rolling farm. For hillier farms, an extra $2000 is required for the pump, and on steeper hills, a different type of irrigator must be used, at a cost of $10,000.

Source: Parminter 1998.

Table A3.2 Annual running costs for a Travelling Irrigator System

	150 – 249 cow herd	250 – 549 cow herd
Repairs and maintenance[1]	$325	$325
Labour[2] @ $10/hr	$340	$595
(turning & moving irrigator)		
Motorbike running @ $7/hr	$238	$416
Electricity	$70 – 140[3]	$70 – 140[3]

[1] Repairs and maintenance are estimated at 5% of capital cost of pump and irrigator
[2] Labour costs for 150 – 249 cow herd:
turning every 4 days – time per turn is 15 minutes
changing paddocks every 16 days – time per shift is 30 minutes
Total time estimated for labour and motorbike running is 34 hours. This has been extrapolated for a 250 – 549 cow herd.
[3] System running ½ - 1 hour per day, 10 HP pump using 7.5 units of electricity per hour @ 7c/unit for a 270 day season

Source: Parminter 1998.

Table A3.3 Costs for a Two-Pond/Contractor Spreading to land System

	150 – 249 cow herd	250 – 549 cow herd
Construction Cost	$4,500	$4,500
Average annual pumping & spreading costs[1]	$3,900	$7,000

[1] These have been averaged from the estimated costs of between $1000 (local Waikato contractor's price) and $1600 (Dairying and the Environment Committee (1996) estimate) per 1million litres, assuming 50 litres/cow/day, for a 270 day season, plus 15% to allow for net of rainfall inputs over evapotranspiration losses. This gives a total of 3 million litres for 196 cows and 5.4 million litres for 350 cows.

Source: Parminter 1998.

Table A3.4 Fertiliser and Production Benefits of Applied Effluent

		(i) Total applied nutrient approach	(ii) adjusted standard fertiliser	(iii) standard fertiliser
Fresh Effluent	Saved fertiliser costs ($)	1390	1390	0
	Production benefits ($)	313 - 938	313 - 938	606 - 1817
	Total annual benefits ($)	1703 - 2328	1703 - 2328	606 - 1817
Stored Effluent	Saved fertiliser costs ($)	1200	960	0
	Production benefits ($)	82 – 247	275 - 826	337 - 1011
	Total annual benefits ($)	1282 - 1447	1235 1786	337 - 1011

Notes:

It cannot be assumed that all farmers would alter the fertiliser regime on the land to which the effluent is applied to compensate exactly for the nutrients from the effluent. Therefore three approaches have been assumed:

(i) Total applied nutrient approach. Here the farmer tailors the fertiliser on the effluent-treated land to apply exactly the same nutrients in total as on the rest of the farm. The saved fertiliser costs are a measure of the dollar value of the benefits of the land-based effluent treatment.

(ii) Adjusted standard fertiliser regime approach. The farmer adjusts the fertilisers applied on the treated block, while minimising the complication to fertiliser management of the farm.

(iii) Standard fertiliser approach. The standard fertiliser programme is applied uniformly to the whole farm, including the block already treated with effluent.

It is then assumed that one-third of farmers follow each strategy, and that the "average" farmer gains half the maximum potential gains from the production effects. This means that the total annual benefits per farm are approximately $1,800 for systems which apply fresh farm dairy effluent to the land. This figure reduces to $1,200 for stored effluent systems.

Source: Parminter 1998.

Table A3.5 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 + principle 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 A3.6 Costs for Land-disposal of Dairyshed Effluent - using a Travelling Irrigator (flat to rolling farmland) - % Total Costs

Capital Cost:		Operating Costs:		saved fertiliser costs:		increased productivity:		Interest Rate	0.07
150 - 249 cows	18000	150 - 249 cows	970	150 - 249 cows	1390	150 - 249 cows	410	term of Loan	15
250 - 549 cows	25000	250 - 549 cows	1475	250 - 549 cows	2430	250 - 549 cows	720		

Region	No. Herds	av herd size	ann. Farm Cost ($)	tot. Regional ann.Farm Cst	Capital Cost	Consent cost*	annual loan pay.	monitor** & annual costs	total annual costs/farm	annual benefit per farm	net annual cost/farm	Total Reg land disp. Cost	% still to convert	additional regional land-disp cst
Northland	1436	172	149296	214389056	18000	0	$1,976.30	33.6	$2,979.90	1800	$1,179.90	$1,694,341	0.24	$406,641.85
Bay of Islands	92	172	149296	13735232	18000	337.5	$2,013.36	67.2	$3,050.56	1800	$1,250.56	$115,051	0.20	$23,010.28
Central Auck.	839	176	186912	156819168	18000	0	$1,976.30	300	$3,246.30	1800	$1,446.30	$1,213,448	0.58	$703,800.08
Sth Auckland	4930	204	216648	1068074640	18000	0	$1,976.30	0	$2,946.30	1800	$1,146.30	$5,651,275	0.30	$1,695,382.50
Bay of Plenty	830	220	244420	202868600	18000	500	$2,031.20	200	$3,201.20	1800	$1,401.20	$1,162,996	0.20	$232,599.29
Taupo	118	424	450288	53133984	25000	0	$2,744.87	0	$4,219.87	3150	$1,069.87	$126,244	0.30	$37,873.24
Rotorua	404	289	321079	129715916	25000	500	$2,799.76	200	$4,474.76	3150	$1,324.76	$535,204	0.20	$107,040.84
West. Uplands	79	256	271872	21477888	25000	0	$2,744.87	0	$4,219.87	3150	$1,069.87	$84,519	0.30	$25,355.82
East Coast	19	173	192203	3651857	18000	0	$1,976.30	0	$2,946.30	1800	$1,146.30	$21,780	0.20	$4,355.95
Hawkes Bay	65	299	332189	21592285	25000	562.5	$2,806.63	77.28	$4,358.91	3150	$1,208.91	$78,579	0.03	$2,357.36
Taranaki	2509	193	214230	537503070	18000	198.75	$1,998.12	56	$3,024.12	1800	$1,224.12	$3,071,329	0.63	$1,934,937.55
Manawatu/Wang	1064	228	236892	252053088	18000	450	$2,025.71	63	$3,058.71	1800	$1,258.71	$1,339,268	0.33	$441,958.55
Wellington	45	205	212995	9584775	18000	120	$1,989.48	57.5	$3,016.98	1800	$1,216.98	$54,764	0.20	$10,952.81
Wairarapa	229	236	245204	56151716	18000	120	$1,989.48	57.5	$3,016.98	1800	$1,216.98	$278,688	0.20	$55,737.62
Nelson/Marl.	341	223	231028	78780548	18000	0	$1,976.30	0	$2,946.30	1800	$1,146.30	$390,889	0.16	$62,542.31
West Coast	371	207	214452	79561692	18000	125	$1,990.03	0	$2,960.03	1800	$1,160.03	$430,370	0.90	$387,333.21
Nth Canterbury	423	378	443772	187715556	25000	600	$2,810.74	200	$4,485.74	3150	$1,335.74	$565,019	0.10	$56,501.90
Sth Canterbury	111	428	502472	55774392	25000	600	$2,810.74	200	$4,485.74	3150	$1,335.74	$148,267	0.10	$14,826.74
Otago	224	301	382872	85763328	25000	0	$2,744.87	0	$4,219.87	3150	$1,069.87	$239,650	0.10	$23,964.99
Waitaki	73	487	619464	45220872	25000	180	$2,764.63	0	$4,239.63	3150	$1,089.63	$79,543	0.10	$7,954.29
Southland	471	345	438840	206693640	25000	250	$2,772.31	159	$4,406.31	3150	$1,256.31	$591,724	0.10	$59,172.40
				3480261303								$17,872,951		$6,294,299.59

Annual National Total Farm Costs: $3,486,555,603

Annual National Net Cost of Dairyshed waste to land: $17,872,951

Environ. Compliance Csts as % Total Csts: 0.51

* where the cost of consent was given as a range of values, the average has been used

** where monitoring is carried out every second year, for a good effective system, the cost of inspection has been halved

Table A3.7 Costs for Land-disposal of Dairyshed Effluent - using a Travelling Irrigator (steeper farmland) - % Total Costs

Capital Cost:		Operating Costs:		saved fertiliser costs:		increased productivity:		Interest Rate	0.07
150 - 249 cows	26000	150 - 249 cows	970	150 - 249 cows	1390	150 - 249 cows	410	term of Loan	15
250 - 549 cows	33000	250 - 549 cows	1475	250 - 549 cows	2430	250 - 549 cows	720		

Region	No. Herds	av herd size	ann. Farm Cost ($)	tot. Regional ann.Farm Cst	Capital Cost	Consent cost*	annual loan pay.	monitor** & annual costs	total annual costs/farm	annual benefit per farm	net annual cost/farm	Total Regional Cost	% still to convert	additional regional land-disp cst
Northland	1436	172	149296	214389056	26000	0	$2,854.66	33.6	$3,858.26	1800	$2,058.26	$2,955,662	0.24	$709,358.81
Bay of Islands	92	172	149296	13735232	26000	337.5	$2,891.72	67.2	$3,928.92	1800	$2,128.92	$195,860	0.20	$39,172.05
Central Auck.	839	176	186912	156819168	26000	0	$2,854.66	300	$4,124.66	1800	$2,324.66	$1,950,390	0.58	$1,131,226.17
Sth Auckland	4930	204	216648	1068074640	26000	0	$2,854.66	0	$3,824.66	1800	$2,024.66	$9,981,575	0.30	$2,994,472.50
Bay of Plenty	830	220	244420	202868600	26000	500	$2,909.56	200	$4,079.56	1800	$2,279.56	$1,892,033	0.20	$378,406.55
Taupo	118	424	450288	53133984	33000	0	$3,623.22	0	$5,098.22	3150	$1,948.22	$229,890	0.30	$68,967.08
Rotorua	404	289	321079	129715916	33000	500	$3,678.12	200	$5,353.12	3150	$2,203.12	$890,060	0.20	$178,012.09
West. Uplands	79	256	271872	21477888	33000	0	$3,623.22	0	$5,098.22	3150	$1,948.22	$153,910	0.30	$46,172.88
East Coast	19	173	192203	3651857	26000	0	$2,854.66	0	$3,824.66	1800	$2,024.66	$38,469	0.20	$7,693.71
Hawkes Bay	65	299	332189	21592285	33000	562.5	$3,684.98	77.28	$5,237.26	3150	$2,087.26	$135,672	0.03	$4,070.16
Taranaki	2509	193	214230	537503070	26000	198.75	$2,876.48	56	$3,902.48	1800	$2,102.48	$5,275,127	0.63	$3,323,330.10
Manawatu/Wang	1064	228	236892	252053088	26000	450	$2,904.07	63	$3,937.07	1800	$2,137.07	$2,273,840	0.33	$750,367.25
Wellington	45	205	212995	9584775	26000	120	$2,867.84	57.5	$3,895.34	1800	$2,095.34	$94,290	0.20	$18,858.02
Wairarapa	229	236	245204	56151716	26000	120	$2,867.84	57.5	$3,895.34	1800	$2,095.34	$479,832	0.20	$95,966.37
Nelson/Marl.	341	223	231028	78780548	26000	0	$2,854.66	0	$3,824.66	1800	$2,024.66	$690,409	0.16	$110,465.46
West Coast	371	207	214452	79561692	26000	125	$2,868.38	0	$3,838.38	1800	$2,038.38	$756,241	0.90	$680,616.61
Nth Canterbury	423	378	443772	187715556	33000	600	$3,689.10	200	$5,364.10	3150	$2,214.10	$936,564	0.10	$93,656.40
Sth Canterbury	111	428	502472	55774392	33000	600	$3,689.10	200	$5,364.10	3150	$2,214.10	$245,765	0.10	$24,576.50
Otago	224	301	382872	85763328	33000	0	$3,623.22	0	$5,098.22	3150	$1,948.22	$436,402	0.10	$43,640.19
Waitaki	73	487	619464	45220872	33000	180	$3,642.99	0	$5,117.99	3150	$1,967.99	$143,663	0.10	$14,366.30
Southland	471	345	438840	206693640	33000	250	$3,650.67	159	$5,284.67	3150	$2,134.67	$1,005,430	0.10	$100,543.02
				3480261303								$30,761,084		$10,813,938.22

Annual National Total Farm Costs: $3,491,075,241

Annual National Net Cost of Dairyshed waste to land: $30,761,084

Environ. Compliance Csts as % Total Csts: 0.88

* where the cost of consent was given as a range of values, the average has been used

** where monitoring is carried out every second year, for a good effective system, the cost of inspection has been halved

Table A3.8 Costs for Land-disposal of Dairyshed Effluent - using a Closed Pond/Contractor Spreading to land system - % Total Costs

Capital Cost: 4500

Contractor spreading costs:
- 150 - 249 cow herd: 3900
- 250 - 549 cow herd: 7000

annual benefit (fert. & prod.)
- 150 - 249 cow herd: 1200
- 250 - 549 cow herd: 2100

Interest Rate 0.07
term of Loan 15

Region	No. Herds	av herd size	ann. Farm Cost ($)	tot. Regional ann.Farm Cst	C.C. Pond	Consent cost*	annual loan pay.	monitor** & annual costs	contractor spreading costs	total annual costs/farm	total annual benefit	land disp. net annual cost/farm	Total Reg. land disp. Cost	% still to convert	additional regional land disp cst
Northland	1436	172	88683	127348788	4500	0	$494.08	33.6	3900	$4,427.68	1,200	$3,227.68	$4,634,942	0.24	$1,112,386
Bay of Islands	92	172	88683	8158836	4500	337.5	$531.13	67.2	3900	$4,498.33	1,200	$3,298.33	$303,446	0.20	$60,689
Central Auck.	839	176	109003	91453517	4500	0	$494.08	300	3900	$4,694.08	1,200	$3,494.08	$2,931,530	0.58	$1,700,287
Sth Auckland	4930	204	109003	537384790	4500	250	$521.52	243.15	3900	$4,664.67	1,200	$3,464.67	$17,080,845	0.30	$5,124,254
Bay of Plenty	830	220	111386	92450380	4500	500	$548.97	200	3900	$4,648.97	1,200	$3,448.97	$2,862,648	0.20	$572,530
Taupo	118	424	109003	12862354	4500	250	$521.52	243.15	7000	$7,764.67	2,100	$5,664.67	$668,432	0.30	$200,529
Rotorua	404	289	111386	44999944	4500	500	$548.97	200	7000	$7,748.97	2,100	$5,648.97	$2,282,185	0.20	$456,437
West. Uplands	79	256	109003	8611237	4500	250	$521.52	243.15	7000	$7,764.67	2,100	$5,664.67	$447,509	0.30	$134,253
East Coast	19	173	111386	2116334	4500	0	$494.08	0	3900	$4,394.08	1,200	$3,194.08	$60,687	0.20	$12,137
Hawkes Bay	65	299	111386	7240090	4500	562.5	$555.84	77.28	7000	$7,633.12	2,100	$5,533.12	$359,652	0.03	$10,790
Taranaki	2509	193	101469	254585721	4500	198.75	$515.90	56	3900	$4,471.90	1,200	$3,271.90	$8,209,191	0.63	$5,171,790
Manawatu/Wang	1064	228	111772	118925408	4500	450	$543.48	63	3900	$4,506.48	1,200	$3,306.48	$3,518,098	0.33	$1,160,972
Wellington	45	205	111772	5029740	4500	120	$507.25	57.5	3900	$4,464.75	1,200	$3,264.75	$146,914	0.20	$29,383
Wairarapa	229	236	111772	25595788	4500	120	$507.25	57.5	3900	$4,464.75	1,200	$3,264.75	$747,628	0.20	$149,526
Nelson/Marl.	341	223	99614	33968374	4500	0	$494.08	0	3900	$4,394.08	1,200	$3,194.08	$1,089,180	0.16	$174,269
West Coast	371	207	99614	36956794	4500	125	$507.80	0	3900	$4,407.80	1,200	$3,207.80	$1,190,094	0.90	$1,071,084
Nth Canterbury	423	378	302311	127877553	4500	600	$559.95	200	7000	$7,759.95	2,100	$5,659.95	$2,394,160	0.10	$239,416
Sth Canterbury	111	428	302311	33556521	4500	600	$559.95	200	7000	$7,759.95	2,100	$5,659.95	$628,255	0.10	$62,825
Otago	224	301	229191	51338784	4500	0	$494.08	0	7000	$7,494.08	2,100	$5,394.08	$1,208,273	0.10	$120,827
Waitaki	73	487	229191	16730943	4500	180	$513.84	0	7000	$7,513.84	2,100	$5,413.84	$395,210	0.10	$39,521
Southland	471	345	229191	107948961	4500	250	$521.52	159	7000	$7,680.52	2,100	$5,580.52	$2,628,427	0.10	$262,843
													$53,787,307		$17,866,749

Annual National Total Farm Costs: $1,763,007,606

Annual National Net Cost of Dairyshed waste to land: $53,787,307

Environ. Compliance Csts as % Total Csts: **3.05**

* where the cost of consent was given as a range of values, the average has been used

** where monitoring is carried out every second year, for a good effective system, the cost of inspection has been halved

Table A3.9 Costs for Land-disposal of Dairyshed Effluent - using a Travelling Irrigator (flat to rolling farmland)

Capital Cost:		Labour Costs:	install irrigator	ann. Operating	Interest Rate	0.07
150 - 249 cows	16000	150 - 249 cow herd	2000	340	term of Loan	15
250 - 549 cows	22000	250 - 549 cow herd	3000	595		
ann. repairs & main:	325					

Costs resulting from Environmental Compliance:

Region	No. Herds	av herd size	ann. Farm CapitalCst	tot. Regional ann.CapitalCst	ann.Farm wages	tot. Regional ann. Wages	Consent cost*	annual loan pay.	monitor** & annual costs	total ann capital farm csts	total ann capital.csts to Region	% still to convert	additional Regional Capital.Cst	annual farm wages	total ann wage.csts to Region	additional Regional Wage Cst
Northland	1436	172	26832	38530752	2580	3704880	0	$1,756.71	33.6	$2,115.31	$3,037,591	0.24	$729,022	$559.59	$803,570	$192,857
Bay of Islands	92	172	26832	2468544	2580	237360	337.5	$1,793.77	67.2	$2,185.97	$201,109	0.20	$40,222	$559.59	$51,482	$10,296
Central Auck.	839	176	33968	28499152	10912	9155168	0	$1,756.71	300	$2,381.71	$1,998,258	0.58	$1,158,990	$559.59	$469,495	$272,307
Sth Auckland	4930	204	39372	194103960	12648	62354640	250	$1,784.16	243.15	$2,352.31	$11,596,901	0.30	$3,479,070	$559.59	$2,758,775	$827,632
Bay of Plenty	830	220	42240	35059200	8800	7304000	500	$1,811.61	200	$2,336.61	$1,939,387	0.20	$387,877	$559.59	$464,459	$92,892
Taupo	118	424	81832	9656176	26288	3101984	250	$2,442.93	243.15	$3,011.08	$355,307	0.30	$106,592	$924.38	$109,077	$32,723
Rotorua	404	289	55488	22417152	11560	4670240	500	$2,470.38	200	$2,995.38	$1,210,133	0.20	$242,027	$924.38	$373,451	$74,690
West. Uplands	79	256	49152	3883008	15872	1253888	250	$2,442.93	243.15	$3,011.08	$237,875	0.30	$71,363	$924.38	$73,026	$21,908
East Coast	19	173	33216	631104	6920	131480	0	$1,756.71	0	$2,081.71	$39,553	0.20	$7,911	$559.59	$10,632	$2,126
Hawkes Bay	65	299	57408	3731520	11960	777400	562.5	$2,477.24	77.28	$2,879.52	$187,169	0.03	$5,615	$924.38	$60,085	$1,803
Taranaki	2509	193	47478	119122302	11387	28569983	198.75	$1,778.54	56	$2,159.54	$5,418,275	0.63	$3,413,513	$559.59	$1,404,009	$884,526
Manawatu/Wang	1064	228	49932	53127648	7980	8490720	450	$1,806.12	63	$2,194.12	$2,334,545	0.33	$770,400	$559.59	$595,403	$196,483
Wellington	45	205	44895	2020275	7175	322875	120	$1,769.89	57.5	$2,152.39	$96,858	0.20	$19,372	$559.59	$25,182	$5,036
Wairarapa	229	236	51684	11835636	8260	1891540	120	$1,769.89	57.5	$2,152.39	$492,897	0.20	$98,579	$559.59	$128,146	$25,629
Nelson/Marl.	341	223	67569	23041029	19401	6615741	0	$1,756.71	0	$2,081.71	$709,864	0.16	$113,578	$559.59	$190,820	$30,531
West Coast	371	207	62721	23269491	18009	6681339	125	$1,770.44	0	$2,095.44	$777,408	0.90	$699,667	$559.59	$207,608	$186,847
Nth Canterbury	423	378	109998	46529154	46872	19826856	600	$2,481.36	200	$3,006.36	$1,271,690	0.10	$127,169	$924.38	$391,014	$39,101
Sth Canterbury	111	428	124548	13824828	53072	5890992	600	$2,481.36	200	$3,006.36	$333,706	0.10	$33,371	$924.38	$102,607	$10,261
Otago	224	301	89397	20024928	27692	6203008	0	$2,415.48	0	$2,740.48	$613,868	0.10	$61,387	$924.38	$207,062	$20,706
Waitaki	73	487	144639	10558647	44804	3270692	180	$2,435.24	0	$2,760.24	$201,498	0.10	$20,150	$924.38	$67,480	$6,748
Southland	471	345	102465	48261015	31740	14949540	250	$2,442.93	159	$2,926.93	$1,378,584	0.10	$137,858	$924.38	$435,385	$43,538
				710595521		195404326					$34,432,477		$11,723,732		$8,928,769	$2,978,642

Percentage of total Capital Cost attributable to environmental compliance = 4.77%

Percentage of total farm wages attributable to environmental compliance = 4.50%

* where the cost of consent was given as a range of values, the average has been used

** where monitoring is carried out every second year, for a good effective system, the cost of inspection has been halved

Table A3.10 Costs for Land-disposal of Dairyshed Effluent - using a Travelling Irrigator (steeper farmland)

Capital Cost:		Labour Costs:	install irrigator	ann. Operating	Interest Rate	0.07
150 - 249 cows	24000	150 - 249 cow herd	2000	340	term of Loan	15
250 - 549 cows	30000	250 - 549 cow herd	3000	595		
ann. repairs & main:	725					

Costs resulting from Environmental Compliance:

Region	No. Herds	av herd size	ann. Farm CapitalCst	tot. Regional ann.CapitalCst	ann.Farm wages	tot. Regional ann. Wages	Consent cost*	annual loan pay.	monitor** & annual costs	total ann capital farm csts	total ann capital.csts to Region	% still to convert	additional Regional Capital.Cst	annual farm wages	total ann wage.csts to Region	additional Regional Wage Cst
Northland	1436	172	26832	38530752	2580	3704880	0	$2,635.07	33.6	$3,393.67	$4,873,312	0.24	$1,169,595	$559.59	$803,570	$192,857
Bay of Islands	92	172	26832	2468544	2580	237360	337.5	$2,672.13	67.2	$3,464.33	$318,718	0.20	$63,744	$559.59	$51,482	$10,296
Central Auck.	839	176	33968	28499152	10912	9155168	0	$2,635.07	300	$3,660.07	$3,070,800	0.58	$1,781,064	$559.59	$469,495	$272,307
Sth Auckland	4930	204	39372	194103960	12648	62354640	250	$2,662.52	243.15	$3,630.67	$17,899,201	0.30	$5,369,760	$559.59	$2,758,775	$827,632
Bay of Plenty	830	220	42240	35059200	8800	7304000	500	$2,689.97	200	$3,614.97	$3,000,424	0.20	$600,085	$559.59	$464,459	$92,892
Taupo	118	424	81832	9656176	26288	3101984	250	$3,321.29	243.15	$4,289.44	$506,154	0.30	$151,846	$924.38	$109,077	$32,723
Rotorua	404	289	55488	22417152	11560	4670240	500	$3,348.74	200	$4,273.74	$1,726,589	0.20	$345,318	$924.38	$373,451	$74,690
West. Uplands	79	256	49152	3883008	15872	1253888	250	$3,321.29	243.15	$4,289.44	$338,866	0.30	$101,660	$924.38	$73,026	$21,908
East Coast	19	173	33216	631104	6920	131480	0	$2,635.07	0	$3,360.07	$63,841	0.20	$12,768	$559.59	$10,632	$2,126
Hawkes Bay	65	299	57408	3731520	11960	777400	562.5	$3,355.60	77.28	$4,157.88	$270,262	0.03	$8,108	$924.38	$60,085	$1,803
Taranaki	2509	193	47478	119122302	11387	28569983	198.75	$2,656.89	56	$3,437.89	$8,625,673	0.63	$5,434,174	$559.59	$1,404,009	$884,526
Manawatu/Wang	1064	228	49932	53127648	7980	8490720	450	$2,684.48	63	$3,472.48	$3,694,717	0.33	$1,219,257	$559.59	$595,403	$196,483
Wellington	45	205	44895	2020275	7175	322875	120	$2,648.25	57.5	$3,430.75	$154,384	0.20	$30,877	$559.59	$25,182	$5,036
Wairarapa	229	236	51684	11835636	8260	1891540	120	$2,648.25	57.5	$3,430.75	$785,641	0.20	$157,128	$559.59	$128,146	$25,629
Nelson/Marl.	341	223	67569	23041029	19401	6615741	0	$2,635.07	0	$3,360.07	$1,145,784	0.16	$183,325	$559.59	$190,820	$30,531
West Coast	371	207	62721	23269491	18009	6681339	125	$2,648.80	0	$3,373.80	$1,251,678	0.90	$1,126,510	$559.59	$207,608	$186,847
Nth Canterbury	423	378	109998	46529154	46872	19826856	600	$3,359.72	200	$4,284.72	$1,812,435	0.10	$181,243	$924.38	$391,014	$39,101
Sth Canterbury	111	428	124548	13824828	53072	5890992	600	$3,359.72	200	$4,284.72	$475,603	0.10	$47,560	$924.38	$102,607	$10,261
Otago	224	301	89397	20024928	27692	6203008	0	$3,293.84	0	$4,018.84	$900,220	0.10	$90,022	$924.38	$207,062	$20,706
Waitaki	73	487	144639	10558647	44804	3270692	180	$3,313.60	0	$4,038.60	$294,818	0.10	$29,482	$924.38	$67,480	$6,748
Southland	471	345	102465	48261015	31740	14949540	250	$3,321.29	159	$4,205.29	$1,980,690	0.10	$198,069	$924.38	$435,385	$43,538
				710595521		195404326					$53,189,809		$18,301,595		$8,928,769	$2,978,642

Percentage of total Capital Cost attributable to environmental compliance = 7.30%

Percentage of total farm wages attributable to environmental compliance = 4.50%

* where the cost of consent was given as a range of values, the average has been used

** where monitoring is carried out every second year, for a good effective system, the cost of inspection has been halved

Table A3.11 Costs for Land-based discharge of Dairyshed Effluent - using a Closed Pond/Contractor Spreading to land system

Capital Cost:	4500	**Contractor spreading costs:**				
		150 - 249 cow herd	3900		**Interest Rate**	0.07
		250 - 549 cow herd	7000		**term of Loan**	15

Region	No. Herds	av herd size	ann. Farm CapitalCst	tot. Regional ann.CapitalCst	ann.Farm wages	tot. Regional ann. Wages	Costs resulting from Environmental Compliance: Consent cost*	annual loan pay.	monitor** & annual costs	total ann capital farm csts	total ann capital.csts to Region	% still to convert	additional Regional Capital.Cst	annual farm wages	total ann wage.csts to Region	additional Regional Wage Cst
Northland	1436	172	26832	38530752	2580	3704880	0	$494.08	33.6	$527.68	$757,742	0.24	$181,858	3900	$5,600,400	$1,344,096
Bay of Islands	92	172	26832	2468544	2580	237360	337.5	$531.13	67.2	$598.33	$55,046	0.20	$11,009	3900	$358,800	$71,760
Central Auck.	839	176	33968	28499152	10912	9155168	0	$494.08	300	$794.08	$666,230	0.58	$386,413	3900	$3,272,100	$1,897,818
Sth Auckland	4930	204	39372	194103960	12648	62354640	250	$521.52	243.15	$764.67	$3,769,845	0.30	$1,130,954	3900	$19,227,000	$5,768,100
Bay of Plenty	830	220	42240	35059200	8800	7304000	500	$548.97	200	$748.97	$621,648	0.20	$124,330	3900	$3,237,000	$647,400
Taupo	118	424	81832	9656176	26288	3101984	250	$521.52	243.15	$764.67	$90,232	0.30	$27,069	7000	$826,000	$247,800
Rotorua	404	289	55488	22417152	11560	4670240	500	$548.97	200	$748.97	$302,585	0.20	$60,517	7000	$2,828,000	$565,600
West. Uplands	79	256	49152	3883008	15872	1253888	250	$521.52	243.15	$764.67	$60,409	0.30	$18,123	7000	$553,000	$165,900
East Coast	19	173	33216	631104	6920	131480	0	$494.08	0	$494.08	$9,387	0.20	$1,877	3900	$74,100	$14,820
Hawkes Bay	65	299	57408	3731520	11960	777400	562.5	$555.84	77.28	$633.12	$41,152	0.03	$1,235	7000	$455,000	$13,650
Taranaki	2509	193	47478	119122302	11387	28569983	198.75	$515.90	56	$571.90	$1,434,891	0.63	$903,981	3900	$9,785,100	$6,164,613
Manawatu/Wang	1064	228	49932	53127648	7980	8490720	450	$543.48	63	$606.48	$645,298	0.33	$212,948	3900	$4,149,600	$1,369,368
Wellington	45	205	44895	2020275	7175	322875	120	$507.25	57.5	$564.75	$25,414	0.20	$5,083	3900	$175,500	$35,100
Wairarapa	229	236	51684	11835636	8260	1891540	120	$507.25	57.5	$564.75	$129,328	0.20	$25,866	3900	$893,100	$178,620
Nelson/Marl.	341	223	67569	23041029	19401	6615741	0	$494.08	0	$494.08	$168,480	0.16	$26,957	3900	$1,329,900	$212,784
West Coast	371	207	62721	23269491	18009	6681339	125	$507.80	0	$507.80	$188,394	0.90	$169,554	3900	$1,446,900	$1,302,210
Nth Canterbury	423	378	109998	46529154	46872	19826856	600	$559.95	200	$759.95	$321,460	0.10	$32,146	7000	$2,961,000	$296,100
Sth Canterbury	111	428	124548	13824828	53072	5890992	600	$559.95	200	$759.95	$84,355	0.10	$8,435	7000	$777,000	$77,700
Otago	224	301	89397	20024928	27692	6203008	0	$494.08	0	$494.08	$110,673	0.10	$11,067	7000	$1,568,000	$156,800
Waitaki	73	487	144639	10558647	44804	3270692	180	$513.84	0	$513.84	$37,510	0.10	$3,751	7000	$511,000	$51,100
Southland	471	345	102465	48261015	31740	14949540	250	$521.52	159	$680.52	$320,527	0.10	$32,053	7000	$3,297,000	$329,700
				710595521		195404326					$9,840,607		$3,375,227		$63,325,500	$20,911,039

Percentage of total Capital Cost attributable to environmental compliance = 1.38%

Percentage of total farm wages attributable to environmental compliance = 29.27%

* where the cost of consent was given as a range of values, the average has been used

** where monitoring is carried out every second year, for a good effective system, the cost of inspection has been halved

Appendix 4

Notation, Equations, and Aggregations for GTAP

Table A4.1 Glossary of relevant GTAP notation

Naming conventions are as follows:

(i) Sets and parameters are denoted in uppercase.

(ii) The *levels* form of variables in GTAP are denoted in uppercase. Percentage changes in variables are denoted in lower case. For instance, *PM(i,r)* is the market price of commodity *i* in region *r* in levels form, and *pm(i,r)* = [*d PM(i,r) / PM(i,r)*] * 100% is the *linearised* form of this variable.

(iii) The GTAP data base comprises only value flows (in their levels form). Data base variables are accordingly written in uppercase. These are declared as coefficients and are updated using percentage changes in the component prices and quantities, after each step in the solution. The data base stores the minimal amount of information.

(iv) Derivatives of the data base variables are also in levels form. There are two types of derivatives: value flows and shares. The derivative variables naturally get updated following each update of the data base.

(v) The model also computes changes in regional equivalent variations and trade balances absolute changes in $US 1995 million. Therefore these variables are written in uppercase.

Sets:

REG	Regions
NSAV_COMM	Non-savings Commodities
TRAD_COMM	Tradeable Commodities
DEMD_COMM	Demanded Commodities
PROD_COMM	Produced Commodities
ENDW_COMM	Endowment Commodities

Value Flows:

VDPA(i,r) value of expenditure on domestic tradeable commodity *i* by private household in region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

VIPA(i,r) value of expenditure on imported tradeable commodity *i* by private household in region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

VPA(i,r) value of private household expenditure on tradeable commodity *i* by in region *r* evaluated at agents' prices $\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

$$VPA(i,r) = VDPA(i,r) + VIPA(i,r)$$

PRIVEXP(r) private household expenditure in region *r* evaluated at agents' prices
$\forall\ r \in$ REG

$$PRIVEXP(r) = \sum_{i \in TRAD\_COMM} VPA(i,r)$$

PSAVE price of composite capital good supplied to savers by global bank

QSAVE(r) quantity of savings demanded in region *r* $\forall\ r \in$ REG

SAVE(r) value of net savings in region *r* $\forall\ r \in$ REG

$$SAVE(r) = PSAVE * QSAVE(r)$$

VDGA(i,r) value of expenditure on domestic tradeable commodity *i* by government household in region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

VIGA(i,r) value of expenditure on imported tradeable commodity *i* by government household in region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

VGA(i,r) value of government household expenditure on tradeable commodity *i* in region *r* evaluated at agents' prices $\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

$$VGA(i,r) = VDGA(i,r) + VIGA(i,r)$$

GOVEXP(r) government household expenditure in region *r* evaluated at agents' prices $\forall\ r \in$ REG

$$GOVEXP(r) = \sum_{i \in TRAD\_COMM} VGA(i,r)$$

VOA(i,r) value of non-savings commodity *i* output or supplied in region *r* evaluated at agents' prices $\forall\ i \in$ NSAV_COMM
$\forall\ r \in$ REG

$$VOA(i,r) = \sum_{j \in DEMD\_COMM} VFA(j,i,r)$$

VFA(i,j,r) value of purchases of demanded commodity *I* by firms in sector j of region *r* evaluated at agents' prices $\forall\ i \in$ DEMD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

REGINV(r) gross investment in region *r* that equals value of output of sector "cgds" $\forall\ r \in$ REG

$$REGINV(r) = \sum_{k \in CGDS\_COMM} VOA(k,r)$$

VDFA(i,j,r) value of purchases of domestic tradeable commodity *i* by firms in sector *j* of region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

$$VDFA(i,j,r) = PFD(i,r) * QFD(i,r)$$

VIFA(i,j,r) value of purchases of imported tradeable commodity *i* by firms in sector *j* of region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

$$VIFA(i,j,r) = PFM(i,r) * QFM(i,r)$$

VXMD(i,r,s) value of exports of tradeable commodity *i* from source *r* to destination s evaluated at (exporter's) market prices
$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG
$\forall\ s \in$ REG

$$VXMD(i,r,s) = PM(i,r) * QXS(i,r,s)$$

Shares:

FMSHR(i,j,r) share of imports in the composite for tradeable commodity *i* used by firms in sector *j* of region *r* evaluated at agents' prices
$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

MSHR*(i,r,s)* market share of source *r* in the aggregate imports of tradeable commodity *i* in region *s* evaluated at market prices

$\forall i \in$ TRAD_COMM
$\forall r \in$ REG
$\forall s \in$ REG

SVA(i,j,r) share of endowment commodity *i* in value-added of firms in sector *j* of region *r* evaluated at agents' prices
$\forall i \in$ ENDW_COMM
$\forall j \in$ PROD_COMM
$\forall r \in$ REG

Quantity Variables:

QO(i,s) quantity of non-saving commodity *i*, output or supplied in region *s*
$\forall i \in$ NSAV_COMM
$\forall s \in$ REG

QXS(i,r,s) quantity of exports of tradeable commodity *i* from source *r* to destination *s*
$\forall i \in$ TRAD_COMM
$\forall r \in$ REG
$\forall s \in$ REG

QFE(i,j,s) quantity of endowment commodity *i* demanded by firms in sector *j* of region *s*
$\forall i \in$ ENDW_COMM
$\forall j \in$ PROD_COMM
$\forall s \in$ REG

QVA(j,r) quantity index of value-added (eg. land labour composite) in firms of sector *j* in region *r*
$\forall j \in$ PROD_COMM
$\forall r \in$ REG

QF(i,j,s) quantity of composite tradeable commodity *i* demanded by firms of sector *j* in region *r*
$\forall i \in$ TRAD_COMM
$\forall j \in$ PROD_COMM
$\forall s \in$ REG

QFD(i,j,s) quantity of domestic tradeable commodity *i* demanded by firms in sector *j* of region *s*
$\forall i \in$ TRAD_COMM
$\forall j \in$ PROD_COMM
$\forall s \in$ REG

QFM(i,j,s) quantity of imported tradeable commodity *i* demanded by firms in sector *j* of region *s*
$\forall i \in$ TRAD_COMM
$\forall j \in$ PROD_COMM
$\forall s \in$ REG

QIM(i,r) quantity of aggregate imports of tradeable commodity *i* demanded by region *r* using market prices as weights

$\forall\ i \in$ TRAD_COMM
$\forall$ r $\in$ REG

QXWCOM(i) volume of global merchandise exports of tradeable commodity *i*

$\forall\ i \in$ TRAD_COMM

QGDP(r) quantity index for GDP in region *r* $\forall\ r \in$ REG

Price Variables:

PS(i,r) supply price of non-savings commodity i in region r

$\forall\ i \in$ NSAV_COMM
$\forall\ r \in$ REG

PM(i,r) market price of non-savings commodity i in region r

$\forall\ i \in$ NSAV_COMM
$\forall\ r \in$ REG

PFE(i,j,r) demand price of endowment commodity i for firms in sector j region r

$\forall\ i \in$ ENDW_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

PVA(j,r) price of value-added in sector *j* of region *r*

$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

PF(i,j,r) demand price of composite tradeable commodity *i* for firms in sector *j* of region *r*

$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

PFD(i,j,r) demand price of domestic tradeable commodity *i* for firms in sector *j* of region *r*

$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

PFM(i,j,r) demand price of imported tradeable commodity *i* for firms in sector *j* of region *r*

$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

PFOB(i,r,s) world (*fob*) price of tradeable commodity *i* exported from source *r* to destination *s* (prior to including transport margin)

$\forall\ i \in$ TRAD_COMM
$\forall\ j \in$ PROD_COMM
$\forall\ r \in$ REG

PMS(i,r,s) market price by source of tradeable commodity *i* imported from source *r* to destination *s*

$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG
$\forall$ s $\in$ REG

PIM(i,r) market price of aggregate imports of tradeable commodity *i* in region *r*

$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

PXW(i,r) price index for aggregate exports of tradeable commodity *i* from region *r*

$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG

PXWCOM(i) price index of global merchandise exports of tradeable commodity *i*

$\forall\ i \in$ TRAD_COMM

PW(i) world price index for total supply of tradeable commodity *i*

$\forall\ i \in$ TRAD_COMM

PSAVE price of composite capital good supplied to savers by global bank

Policy Variables:

TO(i,r) power of the tax on output (or income) of nonsavings commodity *i* in region *r*

$\forall\ i \in$ NSAV_COMM
$\forall\ r \in$ REG

TXS(i,r,s) power of the tax on exports of tradeable commodity *i* from source *r* to destination *s* (levied in region *r*)

$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG
$\forall\ s \in$ REG

TMS(i,r,s) power of the tax on imports of tradeable commodity *i* from source *r* to destination *s* (levied in region *r*)

$\forall\ i \in$ TRAD_COMM
$\forall\ r \in$ REG
$\forall\ s \in$ REG

TX(i,r) power of the variable export tax on exports of tradeable commodity *i* from region *r* – destination-generic

$\forall\ i \in$ TRAD_COMM

$\forall\, r \in$ REG

TM(i,r) power of the variable import tax (levy) on imports of tradeable commodity i in region s – source-generic $\forall\, i \in$ TRAD_COMM
$\forall\, r \in$ REG

Technical Change Variables:

AO(j,r) output augmenting technical change in sector j of region r
$\forall\, j \in$ PROD_COMM
$\forall\, r \in$ REG

AFE(i,j,r) primary factor i augmenting technical change in sector j of region r
$\forall\, i \in$ ENDW_COMM
$\forall\, j \in$ PROD_COMM
$\forall\, r \in$ REG

AVA(j,r) value-added augmenting technical change in sector j of region r
$\forall\, j \in$ PROD_COMM
$\forall\, r \in$ REG

Value and Income Variables:

vxwfob(i,r) percentage change in value of exports of tradeable commodity i from region r using *fob* weights [is identical to the linearised form of *VXW(i,r)*] $\forall\, i \in$ TRAD_COMM
$\forall\, r \in$ REG

valuew(i) percentage change in value of global supply of tradeable commodity i using *fob* weights $\forall\, i \in$ TRAD_COMM

vgdp(r) percentage change in value of GDP in region r $\forall\, r \in$ REG

y(r) percentage change in regional household income in region r
$\forall\, r \in$ REG

Welfare Variables:

EV(r) equivalent variation in region r, in $US million (positive figure indicates welfare improvement) $\forall\, r \in$ REG

WEV equivalent variation for the world, in $US million (positive figure indicates welfare improvement)

Trade Balance Variable:

DTBAL(r) change in trade balance of region r, in $US million (positive figure indicates increase in exports exceeds increase in imports)

$\forall\, r \in$ REG

Source: Padma Swaminathan 1997.

Relevant Production Equations:

Table A4.2 Composite Imports Nest

(1) $pim(i,s) = \sum_{k \in REG} MSHR(i,k,s) * pms(i,k,s)$ $\forall i \in TRAD$

$\forall s \in REG$

(2) $qxs(i,r,s) = qim(i,s) - \sigma_M(i) * [pms(i,r,s) - pms(i,r,s)]$ $\forall i \in TRAD$

$\forall r \in REG$

$\forall s \in REG$

Table A4.3 Behavioural Equations for Producers

Composite Intermediates nest:

(3) $pf(i,j,r) = FMSHR(i,j,r) * pfm(i,j,r) + [1 - FMSHR(i,j,r)] * pfd(i,j,r)$

$\forall i \in TRAD$
$\forall j \in PROD$
$\forall r \in REG$

(4) $qfm(i,j,s) = qf(i,j,s) - \sigma_D(i) * [pfm(i,j,s) - pf(i,j,s)]$ $\forall i \in TRAD$
$\forall j \in PROD$
$\forall r \in REG$

(5) $qfd(i,j,s) = qf(i,j,s) - \sigma_D(i) * [pfd(i,j,s) - pf(i,j,s)]$ $\forall i \in TRAD$
$\forall j \in PROD$
$\forall r \in REG$

Value-added nest:

(6) $pva(j,r) = \sum_{k \in ENDW} SVA(k,j,r) * [pfe(k,j,r) - afe(k,j,r)]$ $\forall j \in PROD$

$\forall r \in REG$

(7) $qfe(i,j,r) + afe(i,j,r) = qva(j,r) - \sigma_{VA}(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)]$

$\forall i \in ENDW$

$\forall j \in PROD$

$\forall r \in REG$

Total output nest:

(8) $qva(j,r) + ava(j,r) = qo(j,r) - ao(j,r)$ $\quad \forall j \in PROD$, $\forall r \in REG$

(9) $qf(i,j,r) + ae(i,j,r) = qo(j,r) - ao(j,r)$ $\quad \forall i \in TRAD$, $\forall j \in PROD$, $\forall r \in REG$

Zero profits (revised):

(10)
$$VOA(j,r) * [ps(j,r) + ao(j,r)] = \sum_{i \in ENDW\_COMM} VFA(i,j,r) * [pfe(i,j,r) - afe(i,j,r) - ava(j,r)] + \sum_{i \in TRAD\_COMM} VFA(i,j,r) * [pf(i,j,r) - af(i,j,r)] + VOA(j,r) * profitslack(j,r)$$

$\forall j \in PROD$, $\forall r \in REG$

Table A4.4 Aggregations

Regions:		Commodities:	
New Zealand		**Milk**	
Australia		**Dairy products**	
Northeast Asia:	Japan	**Other crops:**	Paddy rice
	Korea		Vegetables, fruit, nuts
	Hong Kong		Oil seeds
	Taiwan		Sugar cane, sugar beet
Southeast Asia:	Indonesia		Plant-based fibres
	Malaysia		Crops nec
	Philippines	**Grains:**	Wheat
	Singapore		Cereal grains nec
	Thailand	**Other livestock:**	Bovine cattle, sheep, goats, horses
Canada			
United States			Animal products nec
Central America:	Mexico	**Wool**	
	Central America & The Caribbean	**Forestry**	
		Meats:	Bovine cattle, sheep, goat, horse meat prods
European Union:	United Kingdom		
	Germany		Meat products nec
	Denmark	**Other processed food:**	Vegetable oils & fats
	Sweden		Processed rice
	Finland		Sugar
	Rest of EU		Food products nec
Russia:	Former Soviet Union		
		Manufacturing and Services	
Rest of the World			