BOVINE SOMATOTROPIN AND THE CANADIAN DAIRY INDUSTRY: AN ECONOMIC ANALYSIS

by

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ABSTRACT

Bovine Somatotropin (BST) is a naturally occurring hormone in dairy cows which affects milk production levels (Chalupa and Galligan, 1988). The effects of BST have been known since the 1930's but limited supply of this hormone made any large scale commercial use impossible. Recently a low cost source of BST became available through recombinant DNA technology. This low cost availability of the hormone has led to research experiments which show that recombinant BST can significantly increase a cow's ability to produce milk (Peel and Bauman, 1987; Burton et al, 1987; Soderholm et al, 1988; De Boer et al, 1988).

A number of studies have examined the firm level impacts of BST on the Canadian dairy industry. This present work will build upon these earlier studies by examining the impacts of BST at the both the firm and aggregate levels for all of the dairy producing regions in Canada.

To facilitate this analysis at an aggregate level a linear programming model of the Canadian dairy industry was used. This model describes the dairy sector for each province, including the production, processing, trade and marketing subsectors, and is incorporated into the Canadian Regional Agricultural Model (CRAM), (Webber et al, 1986).

Several scenarios were examined representing different government policy responses with the introduction of BST to the Canadian dairy industry. These scenarios are compared to a 1986

"base case" situation of the dairy industry.

The first scenario examined represents a "no policy change" situation. Provincial quota levels, producer prices, levies and subsidies all remain unchanged and BST adoption rates are assumed for each province. In order to maintain existing milk production levels with BST a 5% reduction in the national cow herd results. This lower number of animals producing the same amount of milk as in the base case results in a 5% increase in dairy producer income at the national level.

In the second scenario the impact of BST on quota values is examined. As in the first scenario all dairy policy instruments remain at 1986 base levels. The decrease in marginal costs for a producer fully adopting BST is then estimated. Using a marginal cost estimate of $32 per hl, the fall in marginal cost was nearly 6% or $2.00 per hl on average for Canada. This results in an 18% increase in what these producers can pay for quota. Using lower marginal cost estimates would result in a greatre increase in this variable and smaller quota increases.

In scenario 3 some of the benefits of BST adoption are passed on to consumers. This is done by allowing production levels to expand such that the difference between farm-gate price and supply price remains the same as prior to the introduction of BST. Quota values remain at their base case level. This resulted in a 2% increase in the national supply of raw milk. In the fluid milk market the supply of standard milk increased by 2% and lowfat milk production increased by approximately 3 percent. In the industrial market cheese production increased by 6%, butter production increased by 2% and skim milk powder production fell by approximately 4 percent.

In the final scenario the benefits of BST adoption are passed on to the taxpayers. This is accomplished by reducing the dairy subsidy by an amount which just offsets the cost savings in each province as a result of BST adoption. This leads to a decrease in the dairy subsidy of $80 million at the national level or approximately 30% of the 1986 subsidy payment.

At the firm level, given the assumptions of this study, the main impacts of BST are a fall in marginal costs of $2 per hl and an increase in quota values of 18%. While these estimates of firm level changes resulting from BST adoption are not trivial they are much less than would be expected with earlier results of milk yield increases of over 25 to 35% accompanied by dry matter feed increases of only 10 to 15 percent (Bauman et al, 1985; Soderholm et al, 1988).

Given the assumed Canadian adoption rates of approximately 50% the aggregate level impacts of BST are more moderate. The national herd size falls by 5% and dairy producer incomes are increased by 5% to produce at the base case 1986 production levels.

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Chapter 1

INTRODUCTION

Technological changes have substantially increased the productive capacity of the agricultural industry (Weersink and Tauer, 1989). These advances in agricultural technology raise many different questions in the production, processing, and marketing sectors of an industry. Recent advancements in biotechnology have led to a low cost method of synthesizing a key hormone in the lactation cycle of dairy cattle. This product, bovine somatotropin (BST), allows a dairy cow to more efficiently utilize feed energy for milk production (Shaver and Nytes, 1987).

This study will examine the impacts of introducing this new product into the highly regulated Canadian dairy industry. The main emphasis will be on both the provincial and national effects of BST introduction. Impacts on the production, processing, trade and marketing aspects of the Canadian dairy industry are examined. Several different scenarios representing possible policy options are evaluated. These scenarios pass the benefits of BST adoption onto either producers, consumers or taxpayers.

1.1 <u>Background: Bovine Somatotropin</u>

BST is a naturally occurring protein in dairy cattle, released from the anterior pituitary gland, which affects the production of milk in a cow throughout the lactation cycle. This natural secretion of BST in lactating dairy cows is positively correlated with milk output at different stages of the lactation (Hart et al, 1980; Bines and Hart, 1982). When exogenous BST is subcutaneously injected into dairy cows the result is significant increases in milk yields (Peel and Bauman, 1987; Burton et al, 1987; Soderholm et al, 1988; De Boer et al, 1988).

BST controls the partitioning of nutrients between tissue synthesis and milk synthesis. By doing so it increases the gross lactational efficiency (milk per unit energy consumed) of a dairy cow (Bauman et al, 1985). As the animal's nutrient requirements are partitioned a higher proportion of the feed consumed goes toward the production of milk (Chalupa and Galligan, 1988). This increased ability to partition nutrients towards milk synthesis is also present in genetically superior cows (Bauman et al, 1985, Peel and Bauman, 1987).

Initially, when BST is injected into a dairy cow, the nutrients required for increases in milk yields are provided by body stores of fatty acids, proteins and glycogen (Chalupa and Galligan, 1988). After this initial phase of a cow being in a negative energy position, feed uptake must be increased to maintain these higher milk yields.

The effects of BST were first discovered in the 1930's when crude extracts from the pituitary glands of slaughtered dairy cattle were injected into cows (Shaver and Nytes, 1987). In 1937 Asimov and Krouze discovered that increases in milk yields were possible with the exogenous introduction of this crude form of BST into dairy cows. These pituitary extracts remained the only source of the hormone up until recently. Approximately 200 cattle are required to produce enough BST for a single animals daily injection (Trelawny, 1986). This made any research difficult and expensive.

In the early 1980's recombinant DNA technology has made possible a lower cost source of this hormone. Using bacteria as hosts and introducing the gene responsible for BST production this technology has led to a large scale synthesis of BST. The first experiments with this recombinantly derived BST were conducted in 1982. These experiments yielded results similar to earlier studies using pituitary BST (Bauman et al., 1982). This has resulted in interest by several large private sector chemical companies in the commercial potential of this hormone (Kalter et al., 1985).

Previous Canadian economic studies on BST have shown this product to be profitable at the firm level. Trelawny (1986) found increases of between 5 and 15 % in short term net returns; excluding the cost of the drug. Tabi and Stonehouse (1988) found that dairy enterprise profitability would be increased for all 3 different representative farms in their model. Oxley et al (1989) calculated an average decrease in marginal cost of 8% with the introduction of BST to the Ontario dairy industry. Based on their assumption of no change in milk prices this would imply an increase in dairy enterprise profitability as well.

1.2 Industry Background

The dairy industry has experienced the effects of technological advancements more than perhaps any other sector of the modern agricultural industry. Falling aggregate herd sizes and a move towards capital intensive large scale dairy operations has resulted in steadily falling producer numbers. These changes have resulted from many different advancements such as bulk milk handling systems, high-tech closely monitored feeding systems, rigid breeding programs accelerated by artificial insemination and embryo transplantation and other technological changes.

These technological advancements were partially responsible for the surpluses and low prices of milk in the late 1950s and early 1960's. Relatively low prices and depressed producer incomes led to the introduction of the Canadian Dairy Commission Act in 1966 (Lavigne and Biggs, 1985). As a result the dairy industry was effectively split into two separate markets, the industrial milk market under the federal Canadian Dairy Commission (CDC), and the provincially controlled fluid market.

The fluid (fresh) milk market is under provincial control with internal pricing and quota levels controlled by their own marketing boards (Barichello, 1987). The markets are spatially isolated with no movements, either interprovincially or internationally, of fresh milk being permitted. Producers generally hold both fluid quota and the industrial milk's market share quota (MSQ). Any production over and above their fresh milk quota goes into the industrial side.

The industrial market is supplied by producers holding MSQ allocated to each province by the CDC. They ship either industrial milk or cream for the production of manufactured dairy products. Incentives to produce over quota are removed through the use of a large levy on over quota milk deliveries by industrial producers. Support prices are set on butter and skim milk powder by the CDC. Any of these products that processors cannot sell on the domestic market are purchased by the CDC. A processors margin is also set by the CDC on a hectolitre of industrial milk. As butter and skim milk powder are very close to being joint products this margin and support prices effectively set the farm gate price of industrial milk.

Support prices are set to balance the supply and demand for butterfat (Short and Cote, 1986). This leads to a surplus in the solid nonfat (SNF) constituents of milk. Skim milk powder is made up almost entirely of SNF so this policy leads to surpluses of powder. World prices of skim milk powder are well below this support price and therefore disposal on the world market entails a loss to the CDC. This loss is partially recovered through a levy on MSQ producers.

This market structure is important to this study as any changes in the dairy industry as a result of the introduction of BST could possibly impact upon it's functioning and it's structure. Any substantial increase in production would have to be marketed and hence both the fluid and industrial markets are affected.

1.3 Problem Statement

BST is different from many past products and innovations which have been introduced to the dairy industry. A virtually immediate yield response is possible and this combined with low capital requirements (self administered through daily injections or longer term implants) could potentially make this technology a commercially attractive new product to producers in the dairy industry. A new technology such as this, which has never been commercially used except in limited research settings, raises a great deal of uncertainty for producers at both the firm and aggregate levels. Consumers and the regulatory governing bodies are also involved.

One of the first issue to be addressed when a new product enters an industry is acceptance by the existing producers. In order to establish aggregate level impacts of BST some insight into the economics of technology adoption must be gained. Questions concerning adoption rates are always difficult to answer, but an analysis of the aggregate level impacts of BST is as dependent on the rate of adoption as the firm level effects.

Given the apparent high degree of managerial ability required to realize these efficiency gains it is likely that there will be a group of producers who will not find BST profitable. These producers constitute the group who are not likely to adopt BST. As with all new technologies producers in this group are concerned about the impact of BST on their farm and associated profit levels.

Efficient producers on the other hand may view this as an opportunity to expand production with given overhead structures. They are however concerned about the impacts of their actions on product prices, quota values and consumer acceptance issues.

The increases in the economic efficiency of milk production which appear possible with the use of BST will result in a lowering in the marginal cost of milk production. If production levels and product prices remain static this means increases in the economic rents to holders of quota and thus increases in quota values. If quota values increase significantly this could exacerbate the already large barrier to entry problems faced by potential new entrants into the industry. Some measure of the expected increase in the value of quota is necessary if the impacts of BST on potential entrants to the dairy sector and existing producers looking to expand the scale of their operations are to be analyzed. There is already concern amongst certain groups that quota values in many areas of the country are too high.

At the aggregate level there is uncertainty about the 'best' policy response to an expected lowering of industry marginal costs. Should producers be allowed to capture all of these rents through increases in the value of quota? Alternatively, some of the benefit could be passed onto consumers by allowing an expansion in quota levels and/or the associated lower milk and dairy product prices. Taxpayers could also capture some of the benefit through reductions in the industrial milk subsidy to offset any benefits to the industry from the introduction of this product. These are important questions facing the industry and those that set policy for the industry.

Consumer groups have also shown concern about the effect of a hormone on dairy products. The possible movement of consumers away from dairy products is of concern to several dairy cooperatives and others representing the interest of producers. There are some consumer groups which advocate the need to avoid 'unnatural' production methods.

There are many possible ramifications with respect to Canada's trade in dairy products if the level of domestic production were to increase. One of the goals of Canadian dairy policy is a balance between domestic supply and demand in butterfat. As mentioned in the previous section this leads to a large surplus of skim milk powder which must be sold at a loss on the world market. If domestic production of industrial market milk were to expand, these exports of skim milk powder would increase, leading to a larger levy on industrial producers. If the supply of butterfat exceeds demand, exports of butter would also become necessary.

If the U.S. producers were to adopt BST and Canada did not, this would further increase the difference in dairy product prices between these countries. Consumer lobby groups may demand lower dairy product prices in this situation.

Other studies have examined firm level effects of BST use in Canada (Trelawny, 1986), the effects on what a farmer is willing to pay for additional quota (Tabi, Stonehouse, 1988) and the impacts of BST adoption on quota values and the number of dairy farms in Ontario (Oxley et al, 1989). This study will differ in that it will analyze the aggregate level impacts of the introduction of BST on the dairy industry for all of the producing regions in Canada.

1.4 Objectives

The major objective of this study is to assess the impacts of a new technology on the Canadian dairy industry. This is an analysis at both the national and provincial levels which includes an examination of changes in the production, processing and marketing sectors. To accomplish this several sub-objectives are stated:

1. To determine both the increases in milk yields and feed concentrates associated with the use of this technology at the firm level.
2. To determine the number of farmers who will adopt this technology, by region for Canada.
3. To measure the aggregate output effects of this technology on the Canadian dairy industry.
4. To examine several different government policy options that may be followed by the industry and draw conclusions based upon the results of this analysis.

1.5 Research Procedure

In order to achieve these given objectives the following research procedure has been followed:

1. Experimental data from a full lactation study on the effects of recombinantly derived BST from the University of British Columbia Research Farm, Oyster River will be analyzed (de Boer et al, 1988). Average changes in concentrate feed utilization and milk production levels between a group of control animals and cows receiving 20.3 mg exogenous BST will be estimated based on this data. These animals are at different stages of maturity ranging from first lactation heifers to mature cows in their final lactation. This data together with that from other sources provides the basis for firm level changes expected with the adoption of BST.
2. A review of theory on the adoption of technology and discussion with industry experts has provided a basis on which to make assumptions about the adoption rates of BST, by province, in Canada. Using data from the Oyster River study and assumed adoption rates, a set of input and yield coefficients was calculated for a representative farm for each production region, before and after the introduction of BST. These data and coefficients relate to the consumption of the feed concentrates, forage and pasture, cash costs, high

quality and low quality beef yields, and the production of milk.

3. In order to establish impacts of this adoption at the national and provincial levels it was necessary to modify an existing national level dairy model developed by Short and Cote (1986) to cater to the manufacturing and marketing activities of the industry. This model had fixed supplies of fluid and industrial milk, a single national level processing sub-sector and national level demands for several final dairy products. For use in this study this model was changed to a provincial level model and updated to a 1986 base year. This dairy processing and marketing model was then incorporated and became part of the structure of the Canadian Regional Agricultural Model (CRAM), (Webber et al, 1986). CRAM has provincial level dairy production activities to supply milk to the new provincial processing and marketing subsectors. Trade links, both interprovincially and internationally, were added to facilitate transport of the industrial market final products. This required redefining the structure of CRAM, the programming of several new Fortran subroutines into a matrix generator routine and the creation of associated data files providing the necessary coefficients for the dairy sub-sectors and modification of the structure of the CRAM model. Data sources for

these coefficients and the opening herd size include sources such as the Dairy Commodity Coordination Unit of Agriculture Canada, Statistics Canada, the Canadian Dairy Commission and the Dairy Farmers of Canada.

4. Four scenarios representing different government policy options and a 'base case' were analyzed. The fist situation involved a no policy change case. Other scenarios pass the benefits associated with BST adoption on to one of 3 groups of economic agents: producers, consumers or taxpayers. With the adoption of BST and increased yields aggregate herd size will fall to meet current quota production levels which limit the amount of milk produced. This first scenario passes the full benefit from the introduction of BST to dairy producers. In the second scenario each provinces representative farm is assumed to be a low cost producer. Low cost producers tend to set the price of quota as they can bid up the price to a higher level than less efficient producers can profitably pay. The change in variable costs for an operation which adopts BST should yield information on the change in quota values following the adoption of BST by firms in the Canadian dairy industry. The third scenario allows production limiting quota levels to expand but assumes that quota values stay constant under the new cost structure with BST introduction. This passes some of the benefits of BST to the second group

of economic agents, consumers. The fourth situation to be analyzed involves a reduction in the dairy subsidy which offsets the change in variable costs from the adoption of BST. This scenario will pass the full benefit of BST on to taxpayers.

1.6 Thesis Guide

The second chapter outlines theory relevant to this analysis. Firm level effects of a new technology are first presented by examining the effects on production isoquants and cost curves. This is followed by a discussion of the economic theory concerning technology adoption. Finally a theoretical model of a supply controlled industry with a shifting supply curve is presented.

The third chapter presents the data used in this study from the results of an experiment at the University of British Columbia Research Farm, Oyster River. A summary of the final report on the first lactational results from this experiment at Oyster River by De Boer et al is presented. The assumptions on the cost of BST and the adoption rates to be used in this study are also presented.

Chapter 4 begins with the conceptual details of the dairy model in CRAM. An empirical model is presented in the second section of this chapter. Data relevant to this study and the format of certain files are noted.

The fifth chapter details the scenarios to be examined in this study and the results of this analysis are noted. These scenarios are compared to a 1986 base year. Finally, chapter 6 presents the summary and conclusions of this study. Policy implications are discussed along with the limitations of the study and recommendations for further research.

Chapter 2

Theoretical Considerations

The purpose of this chapter is to provide some economic theory into adoption theories that explain the introduction of a new technology. Basic production economics at the firm level will be reviewed and combined with the economics of technology adoption. Having attempted to set adoption rates at the firm level based on this theory this is used to introduce some industry level effects of the adoption of a new technology by the firms in that industry.

2.1 Production Effects of BST

The principal effect of BST is an increase in the technical efficiency of milk production of the animal through an improvement in the animals feed conversion ratio. Most previous studies estimate that the consumption of feed increases proportionally less than the increases in milk yields (Bauman et al, 1985, Soderholm et al, 1988). A recent study by De Boer et al (1988), with a large sample group, determined that the increases in the concentrate portion of an animals total feed intake are as great as the increases in milk production. However, as the number of animals required to produce a given amount of milk decreases there should be a fall in both the forage portion of the feed intake and the other factors associated with milk production (replacement animals, overhead, energy, veterinary, etc.).

The general effect of this new technology is hypothesized as shown in Figure 2.1. Holding other factors constant, more milk can be produced for a given level of total feed inputs (forages and concentrates). Prior to the adoption of BST the output level y^0 is produced using x units of feed. After BST is adopted this same quantity of feed produces y^1 units output. The production function has thus shifted upwards as a result of this new technology.

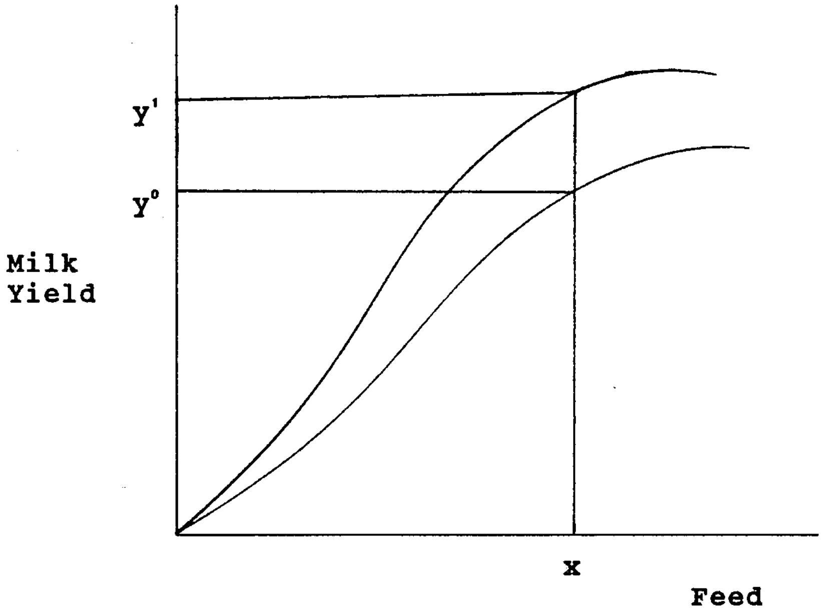

Figure 2.1: Effect of BST Adoption on milk Production Function

The effect of BST introduction is shown in two factor space in Figure 2.2. Prior to the new technology the isocost line A^0B^0, representing the price ratio line of two factors $(- px_2 / px_1)$, is tangent to the isoquant y_1^0 at point c. The marginal rate of substitution (dx_1 / dx_2) between feed (x_1) and labour (x_2) given as $-(\partial y / \partial x_2) / (\partial y / \partial x_1)$ is equal to the ratio of the prices of the two factors ($- px_2 / px_1$). At this point x_1^0 units of feed and x_2^0 units of the other factor represent the low cost combination to produce a given output level.

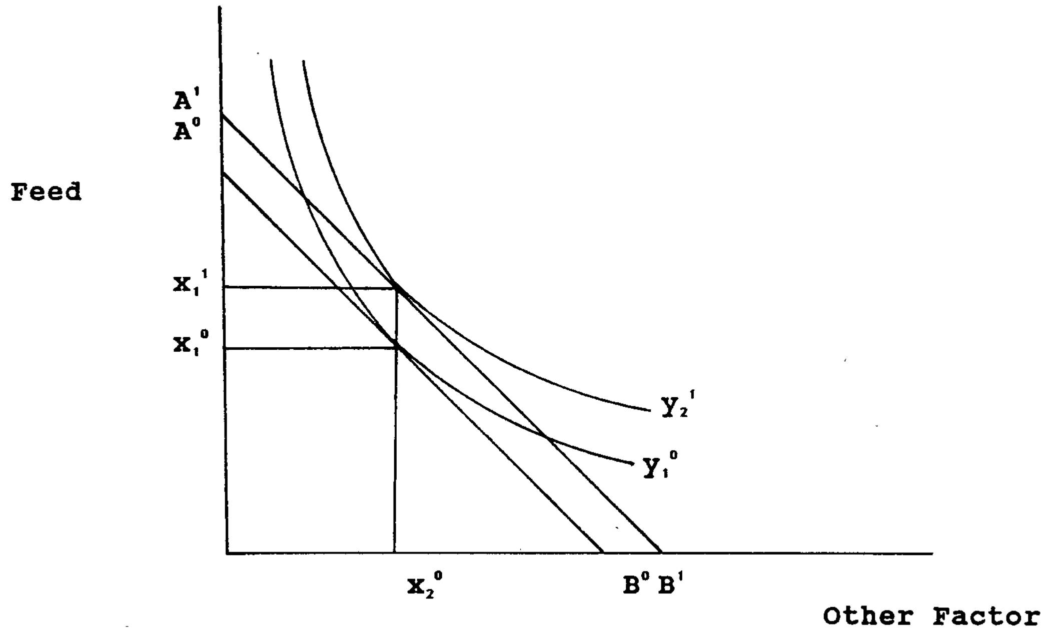

Figure 2.2: Effect of BST Adoption in Two Factor Space, Herd Size Constant

After BST is introduced it is hypothesized that the farmer produces on the higher isoquant y_2^1 using the same amount of factor x_2 but more of x_1. This is shown in Figure 2.2 by the tangency of the isocost line A^1B^1 and y_2^1. The factor price ratio (excluding the cost of BST) and thus the MRS will not have changed.

Alternatively, if the farmer wishes to produce the same quantity of milk after the adoption of BST, as prior, the isoquant representing this equivalent production level will be y_1' in Figure 2.3. Less feed will be required to maintain this level of production but there will be a larger reduction in the use of the other factor (ie: $x_1^0 - x_2^1 > x_1^0 - x_1^1$). This occurs as a result of the smaller herd size required to produce the same level of milk output for a farm since all cows are now producing higher yields.

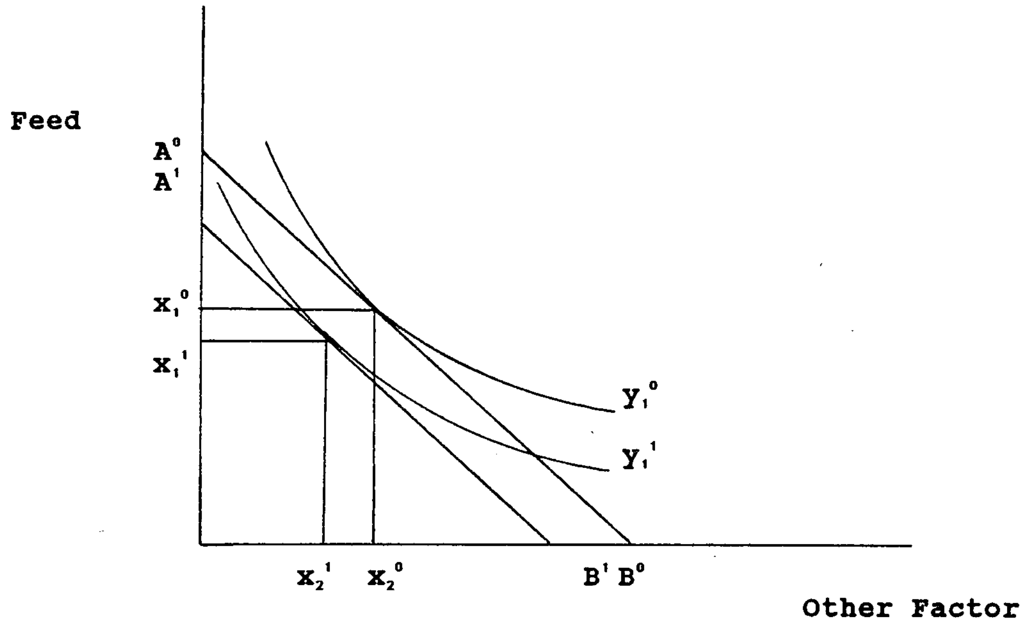

Figure 2.3: The Effect of BST Adoption in Two Factor Space, Production Level Constant

In this latter model it is assumed that with production of milk, both at the firm and aggregate levels constrained by quotas, it will be necessary for a firm to adjust cow numbers to compensate for increased yields. Current production levels could be maintained using smaller herd sizes which would imply less resource requirements by an individual producer. Feed levels would decrease a small amount but other factors to maintain the herd would fall more significantly.

2.2 The Cost Effects of BST on Dairy Producers

Analogous to the shifting of a production function of section 2.1 after the introduction of BST, is a downward shift in the average cost curve of a firm. With the smaller herd size and the subsequent reduction in factors required to produce at this level, costs for any given production level will be lower after the introduction of the new technology. The shifts in both the average and marginal cost curves as a result of BST adoption are hypothesized as shown in Figure 2.4.

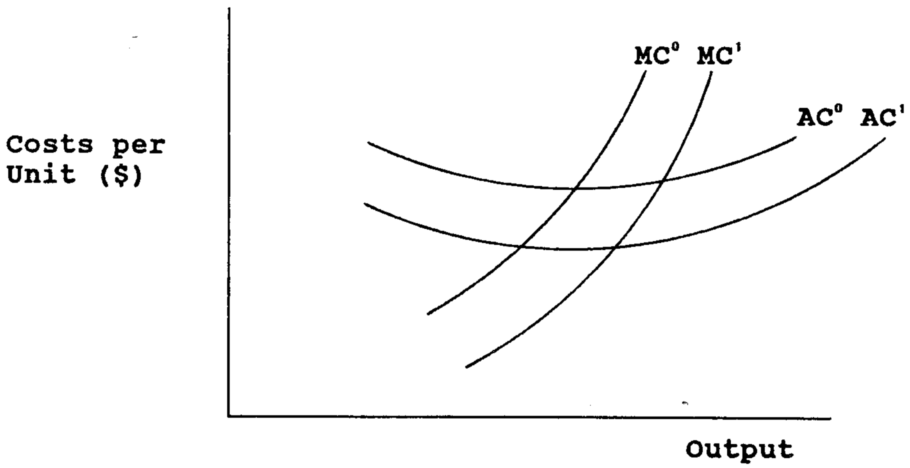

Figure 2.4: Cost Curves Before and After the Adoption of BST

The marginal cost curve shifting to the right as a result of the adoption of BST will result in the industry short run supply curve shifting down to the right as well. This occurs because the industry supply curve is derived by summing the marginal cost curves horizontally. The impacts of the shifting supply curves will be examined in section 2.4.

2.2 The Economics of Technology Adoption

A key assumption in this study concerns the rate of adoption of BST for firms and the impacts of these adoption rates on the dairy sectors in each province. Previous Canadian studies have addressed the effects of BST at the firm level, however to analyze regional effects some understanding of adoption rates by all producers across all regions in Canada is important.

It was suggested by Mansfield (1968) that a firm's probability of accepting a new technology is a function of the firm's size, the proportion of firms in the industry already using it, the profitability of the technology and the investment required. Coombs et al (1987), referring to the epidemics model of diffusion, suggest these same explanatory variables as Mansfield but added those variables relating to management quality and rate of industry growth. Along with the probability of acceptance the length of time over which those who choose to adopt is also important.

A key assumption in this study is that an important factor concerning whether or not a dairy producer accepts BST is profitability. This assumption is based on Canadian dairy farmers being well educated persons making rational business decisions with the ultimate goal being profit maximization.

The idea of a new technology being adopted by an industry over time is referred to in the literature as a diffusion process. The generally accepted shape of a new technologies' diffusion through an industry is often given as the sigmoid curve (Waterson, 1984; Coombs et al, 1987) as shown in Figure 2.5. Adoption is generally quite slow as a product first enters an industry, as more producers use the product and have success with it the rate of diffusion enters the take-off stage, the very steep portion of the curves in Figure 2.5, this rate again slows as it reaches the point of maximum diffusion given as point A. The slope of this curve along its various segments will depend on the new innovation.

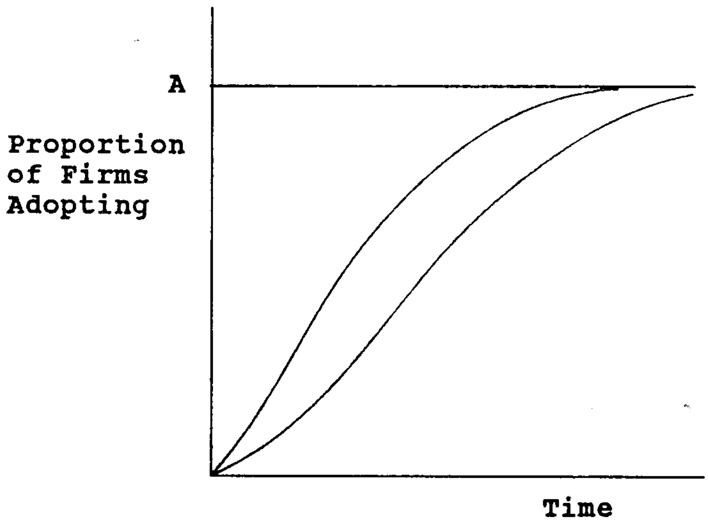

Figure 2.5: Sigmoid Curve Representing the Diffusion Process of a New Technology into an Industry

The steeper of the two curves in Figure 2.5 is meant to represent a new technology, such as BST, where the benefits are almost immediate, and coupled with low capital outlays. As an alternative a curve representing a technology with higher capital requirements (ie, a computer feeding system) is illustrated. The relatively simple, low cost technology is expected to be adopted more quickly as the risks associated with the product not being profitable are much lower than with the more capital intensive product.

The important point illustrated in Figure 2.5 for this study is the point A. This represents the maximum adoption rate for the new technology over the long run. In theory if the benefits associated with a new technology are greater than the costs the proportion of firms adopting this technology will equal 100 percent. In the dairy industry with BST this point needs to be determined. There is a high degree of managerial skill required to make BST use profitable. Hence it is argued that some segment of the industry will not adopt. Assumptions concerning these adoption rates for this study will be further detailed in chapter three.

2.4 Industry Level Effects of BST Introduction

It has been argued that a new technology generally comes about either as a 'technology push' or as a 'demand pull' by market forces (Waterson, 1984). Generally, technological improvements resulting from demand pressures are due to products which are clearly superior to their predecessors (ie: automobiles, stereos etc). As milk produced from BST treated cows is not distinguishable from or superior to milk from non-treated cows it is assumed this technology results from the technology push side.

Under supply management and production limited through quotas the dairy industry with BST can be expected to increase returns through a lowering of costs rather than by unconstrained output expansion. The use of BST allows for increases in economic efficiency by allowing more output to be produced from a given valued bundle of inputs. This implies a lower marginal cost at any positive output level.

A simple model, based on Waterson (1984), can be presented for the effects of a new technology introduction into a supply managed industry. The quantity demanded (q) can be thought of as:

$$q = q(p) \qquad (2.1)$$

where p=own price.

On the supply side the level of technology enters into the cost function. The cost of production is represented as:

$$c = c(q,r) + R \qquad (2.2)$$

where c = total cost, r = technology level, R = direct cost of technology and q = the output level. The level of technology used negatively affects the direct production costs (ie: c / $r < 0$). However, offsetting this is the actual cost of the technology, R. If R exceeds the reduction in direct production costs the product will not be adopted into the industry.This leads to a profit function for the supply managed producer of the form:

$$\pi = p(q) * q - c(q,r) - R \qquad (2.3)$$

Only the cost portion of the profit function is affected by new technology if product price is held constant. However, With the negative publicity surrounding BST use in the dairy industry the demand side may be affected as well. If consumers decrease their consumption of milk as a result of BST this would result in a downwards shift in the milk demand curve. This would negatively affect the profit function having an offsetting effect on the cost savings associated with BST.

The introduction of this new technology into a supply managed industry assuming no change in consumer preferences is shown in Figure 2.6. Prior to the new technology the supply curve is S^0, the demand curve D and the quota level is set at Q. The farm-gate price for the product will be 0a with a supply price equal to 0b. This implies profits equal to the area of the rectangle abef. The marginal benefit from an extra unit of quota is the distance ab. Assuming a competitive secondary trading market for quota this will be the annual rental value of a unit of quota.

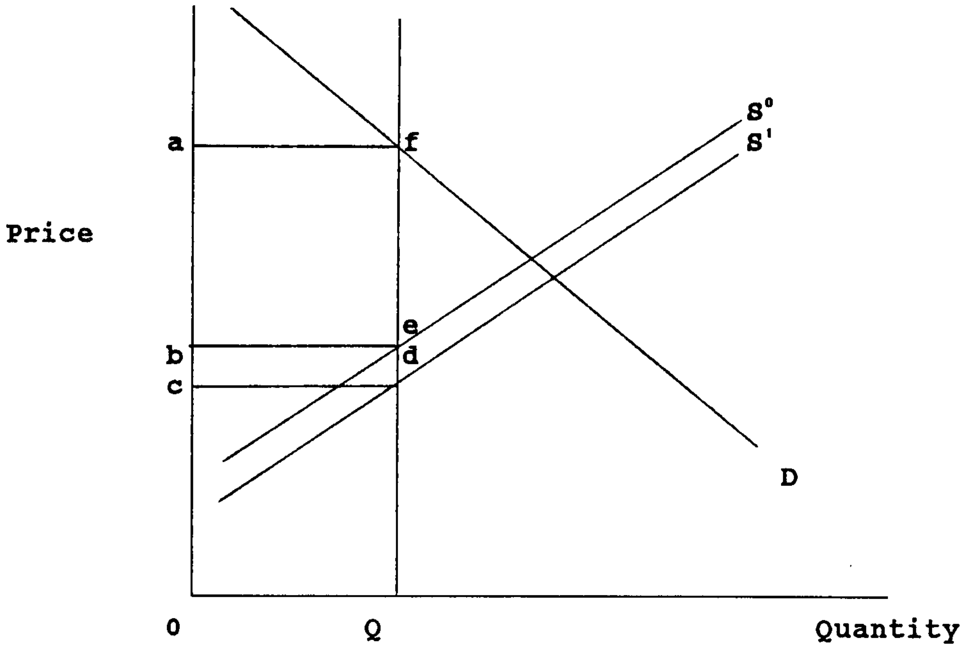

Figure 2.6: Effect of a New Technology Entering a Supply Managed Industry, No effect on Demand

With the introduction of this new technology the supply curve shifts down to S^1. Given the assumption that the producer price for the product is not affected the supply price falls from 0b to 0c. The result of this is an increase in profits equal to the area bcde. The marginal value of an extra unit of quota will now have increased to ac.

Although supply managed industries such as the Canadian dairy industry have some monopoly power it is unlikely they will act as profit maximizing monopolists. When supply management is first initiated in an industry it is not readily possible to pull back production levels to produce at a lower level than the free market equilibrium point. Moving production to a point in which monopoly rents are possible entails decreases in production. This ultimately leads to some producers being forced out of production. It is more likely that production would be fixed and the industry authorities would rely on the expansion of demand to move away from the competitive solution. If it is assumed that the Canadian dairy industry has production quotas set at some intermediate level between the competitive and monopoly solutions, the benefits of BST to the dairy producers would be maximized by maintaining existing production levels.

Alternatively, if it is assumed that a supply managed industry is acting as a profit maximizing monopolist quota levels will be set such that MR = MC, or at Q^0 in Figure 2.7. With a downward shifting supply curve the new profit maximizing output level will be Q^1. This results in a decrease in farm-gate price from P^0 to P^1. For an industry producing at Q^0 maximizing the benefits from a new technology which lowers the marginal cost of production results in an expansion of output.

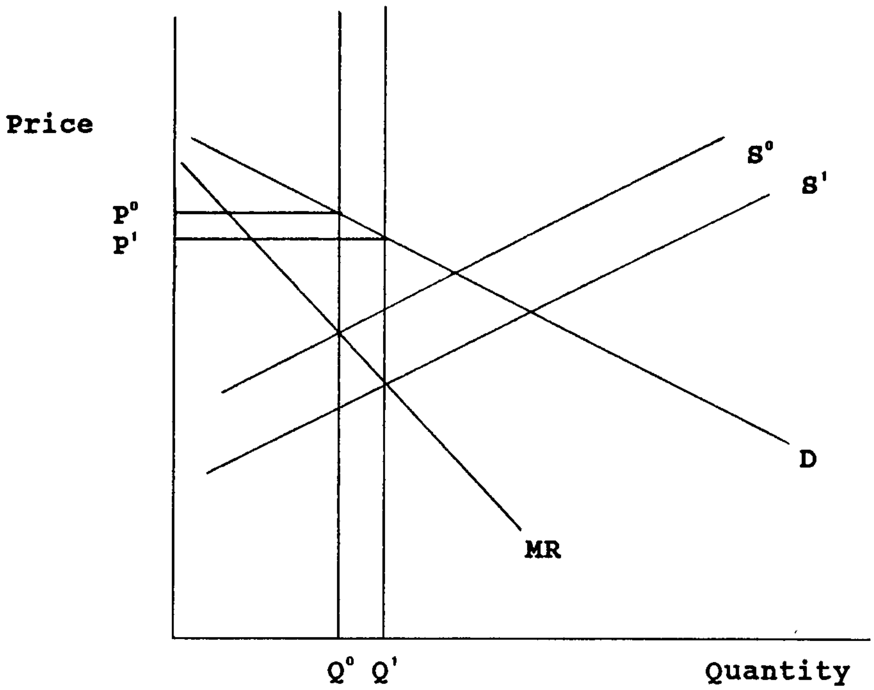

Figure 2.7: Monopoly Industries Profit Maximizing Points Before and After the Introduction of a New Technology

On the other hand, if consumers rather than producers in a supply managed industry are to capture the benefits of a new technology which lowers marginal costs production would be expanded. Any expansion in production quotas and the resulting lower prices would benefit consumers. To maximize consumer benefit without negatively affecting producers production levels could be expanded to the point illustrated as Q^1 in Figure 2.8, with farm-gate product price PD^1 and supply price PS^1. The point Q^0 represents the quota level prior to BST with farm-gate product price PD^0 and supply price PS^0. If production were allowed to expand to Q^1 after the introduction of BST the distance between farm-gate product price and supply price would remain the same as prior to BST. This would imply quota values would not change in this situation with the introduction of BST.

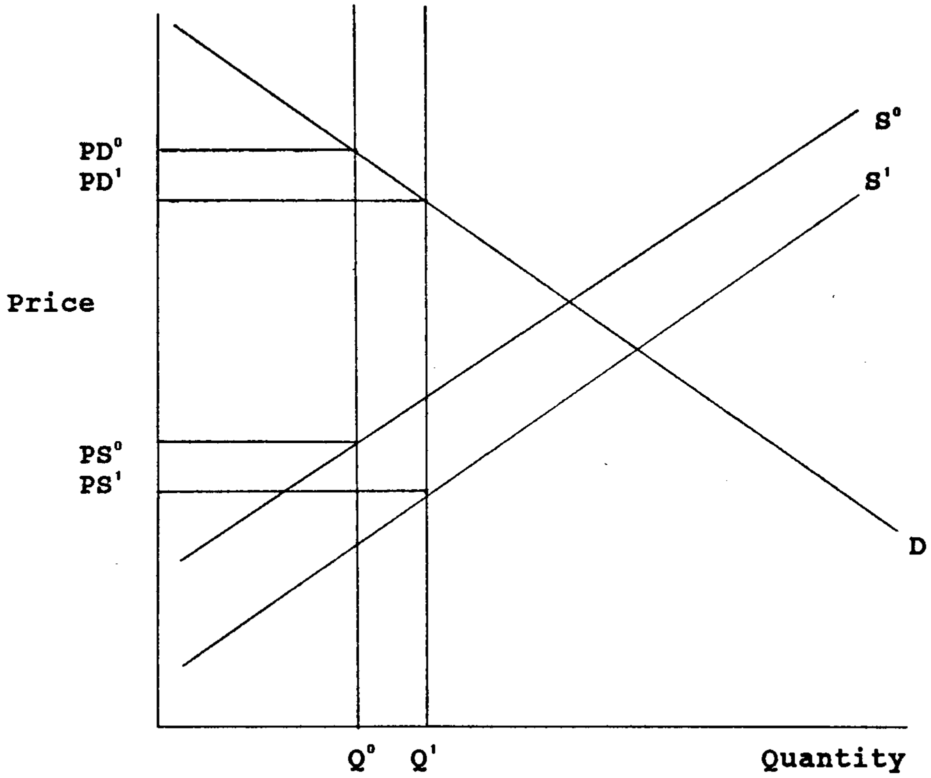

Figure 2.8: Maximizing Consumer Benefit With the Introduction of a New Technology Which Lowers Production Costs

2.5 Related Studies

A large number of biological studies on the effects of BST on milk yields and feed requirements of dairy cattle can be found. For example, Bauman et al (1985) reported an experiment with both pituitary and recombinantly derived BST. With 20.6 mg per day of BST, milk yields increased 16% with the pituitary derived BST and by 36% with the recombinantly derived BST. Net energy intake for the recombinantly derived BST group was 16% greater than for the control. Burton et al (1987) with a 25 mg per day dosage over 266 days had a yield increase of 18% combined with an increase in dry matter uptake of 5%. Soderholm et al (1988) had a yield increase of 25% with a group of cows receiving 20.6 mg per day while dry matter uptake increased by 10% over the control group. De Boer et al (1988) had an overall increase in milk yields for a group of dairy cows and first lactation heifers of 11.8% with an increase in the uptake of feed concentrates (not dry matter uptake) of 12.5%. This study used a much larger sample size with 35 control animals and 37 receiving the 20.6 mg per day dose of BST (next largest of studies mentioned had 10 cows per group). These studies show that BST significantly increases a cow's milk yields and this is accompanied by an increase in feed. However, total feed consumption in most of these studies increases by less than milk yields.

Turning to Economic studies there have been three economic studies in Canada on the effect of BST of interest. Trelawny (1986) measured changes in variable returns from BST on three different types of dairy farms categorized by different levels of capital and management inputs. The short-term net farm returns from adoption, excluding the cost of administering the hormone, ranged between 5 and 15% depending on the combination of farm resources and yield response. These results suggested that BST use would not favour either small, medium or large farms but rather a manager with superior feeding skills.

Tabi and Stonehouse (1988) assumed a given cost of BST to the farmer and measured the impacts of the hormone on the amount a farmer could afford to pay for quota for three categories of farms similar to those selected by Trelawny. The main result is that the amount farmers could pay for additional quota would increase between 8 and 29% depending on the type of quota and the farm's level of technology. Low technology farms with a higher proportion of MSQ showed the greatest percentage increase in what they could profitably pay for quota. Likewise, Oxley et al (1989) attempted to measure the impacts of BST on quota values for dairy producers in Ontario. The rental value of quota was found to increase by 23 percent. BST also resulted in a 5% decrease in the number of dairy producers.

An aggregate level analysis on the impacts of BST on the US dairy industry by Fallert et al (1987) examined the changes in cow numbers, milk prices, production, product use and government expenditures, by region, under different scenarios representing different support prices to the industry. The main finding of this study was that under each of the scenarios increases in revenues exceeded the cost increases associated with BST. The regional location of milk production and the relative size of farms did not change as a result of BST adoption. The number of dairy farms in the U.S. would decrease as a result of BST.

2.6 Summary

This chapter has presented economic theory explaining the introduction of a new technology into a supply managed industry. The firm level effects of the new technology were first examined then industry level impacts detailed.

There have been a number of technical studies on the biological effects of BST showing significant increases in a cow's milk yields. Most firm level economic studies in Canada show BST's benefits to outweigh it's costs. There have been few industry level studies on the impacts of BST adoption. None were located for the Canadian dairy industry.

The main conclusion from the firm level studies is that it would be profitable for a producer to adopt BST in Canada. Net farm returns would increase and this increases the amount farmers would be willing to pay for additional quota.

Chapter 3

The Oyster River Farm Experiment

This chapter will present data specific to BST to be used in this study. This includes a description of a BST research experiment conducted at the University of British Columbia Research Farm which provides biological data on milk yield and feed use changes with this product. Assumptions regarding the cost of BST and the costs of the dairy ration are also detailed. Rates of adoption assumed for each province in this study are also discussed.

3.1 Oyster River Experiment

Data on changes in milk yield and the uptake of feed concentrates used in this study for dairy cattle injected with BST were obtained from research results of an experiment (B-86-49) conducted at the University of British Columbia Research Farm, Oyster River. This study by De Boer and Kennelly is based on research by Shelford, Peterson and Holbek of University of British Columbia. The study reports on results from the first lactation of cows injected with BST at the Oyster River Farm.

Data for this experiment covered 108 Holstein cows comprised of 79 mature cows and 29 heifers. These animals were assigned to one of three different treatment categories. The control consisted of 35 animals which received injections of 2 ml sterile saline per day. The low dosage category consisted of 37 animals receiving 10.3 mg per day of recombinantly derived BST in 1 ml sterile saline. The high dosage category received 20.6 mg of the BST per day in 2 ml sterile saline and contained 36 animals.

Injections were given daily in the neck region on alternating sides with a 20 gauge needle. These injections began at between the 28th and 35th day of lactation and continued up to 70 days prior to calving. This resulted in a total treatment time of 266 days.

Feed concentrates were fed via a computer feeding system. Cows producing in excess of 28 kg per day were fed 1 kg concentrate per 2.5 kg milk produced. Lower yielding cows received 1 kg concentrate per 3 kg milk produced. The concentrate ration consisted of 40% barley, 30% mill run, 21% canola meal and the remainder of salts and minerals. All of the cows in this experiment received the same ration.

Forage consisted of hay, grass and corn silage, and pasture. Forage was freely available to all cows and no measurement of the amount consumed was taken.

Cows were milked twice per day and the milk yields for each animal were recorded. The milk composition including fat content, lactose and somatic cells were analyzed for two consecutive milkings each week. This data on the milk along with the consumption of feed concentrates were averaged for each four week period. Also recorded, on a per animal basis, were the body weights and body condition scores.

The Oyster River experiment began with 108 cows but this number fell to 102 as six cows had early health problems. These health problems were not necessarily associated with BST. Data from these six animals were not included in the results on milk yields and feed consumption but were included in the results pertaining to health and reproduction.

Milk yield and feed use levels are measured over a 32 week period. A large number of the animals had their lactations terminated between the 32nd and 40th week of lactation due to low production levels or the need for a 70 day dry period.

Important summary results on milk yield and feed use changes in this study are given in Table 3.1. Heifers showed very little change in either feed uptake or milk yields with either the low dosage or high dosage levels of BST. Cows showed increases in milk yields of approximately 11% with 10.3 mg per day of BST and 18% with 20.6 mg per day. This was accompanied by an increase in feed concentrates of 11% for the low dosage animals and 18% for the high dosage category.

Table 3.1: Results from Oyster River on Concentrate Feed Uptake and Milk Yield Changes Using BST, kg/day

	Concentrate Feed Level			Milk Yields		
	Dose of BST (mg/day)			Dose of BST (mg/day)		
	0	10.3	20.6	0	10.3	20.6
	(---------kg/day---------)			(--------kg/day-------)		
Cows	14.2	15.8	16.8	35.4	39.3	41.7
Heifers	12.2	12.3	11.7	29.9	30.5	28.6
Total	13.6	14.7 (8.1)[a/]	15.3 (12.5)	34.0	36.5 (7.4)	38.0 (11.8)

Source: De Boer et al, 1986

[a/] % changes from control group in parenthesis

Overall, for the mixed herd, milk yields were 7.4% greater with daily injections of 10.3 mg BST and 11.8% greater with 20.6 mg per day. Concentrate feed increases with BST were 8.1% greater with the low dosage group over the control and 12.5% greater with the high dose category for the mixed herd. The composition of the milk did not change across the three groups.

Table 3.2 shows the shows that body weights and condition scores are not significantly changed by either dose of BST. The overall average body weight was 3 kg less with the low dosage and 2 kg less with the high dosage. Condition scores were also nearly identical between the groups.

Table 3.2: Results from Oyster River on Body Weight and Condition Scores for Cows Using BST

	Body Weight (kg) Dose of BST (mg/day)			Condition Score Dose of BST (mg/day)		
	0	10.3	20.6	0	10.3	20.6
Cows	632	633	641	3.1	3.1	3.1
Heifers	549	549	526	3.0	3.0	2.9
Total	611	608	609	3.1	3.0	3.0

Source: De Boer et al, 1986

There were no noticeable changes in reproductive performance or in the health of cows treated with BST in the Oyster River experiment during this single lactation period. Likewise, the weights of calves born to cows treated with either dose of BST were not different than those born to the control group.

Results from this Oyster River experiment used in this study include the changes in milk yields and concentrate feed consumption between the control group and the 20.6 mg per day BST treatment group. This higher dosage of BST is the closest to the optimal found in clinical trials of 25 mg per day (Oxley et al, 1989).

The Oyster River experiment differs from previous studies primarily in the size of the different groups receiving BST. The average number of animals in the previous Canadian studies was from 8 to 12 per group. The Oyster River study also uses a mixed herd of both mature cows and heifers. Careful attention was paid not to overmanage the herd, thus biasing the results. This adds to the credibility of the results when attempting to utilize them to model dairy producers in the industry. The herd at Oyster River is a high yielding herd compared to commercial dairy herds or even other Canadian experimental herds.

3.2 Cost of BST

Another difficult question with a new technology is what the manufacturers will charge. Nobody knows what the pharmaceutical companies are going to price BST at. They will want to maximize the rents associated with BST. In the U.S. drug companies have indicated that they feel dairy farmers will not adopt BST unless they can obtain a $2 net return for each $1 in BST purchase cost (Fallert et al, 1987).

The assumption about the cost of BST used in this study are similar to those used by Tabi and Stonehouse (1988). The cost of BST is based on a Cornell study which indicated the production costs to the pharmaceutical companies for the hormone to be equivalent to a range of $0.06 to $0.15 US per cow per day depending on the scale of production (Kalter et al, 1985). Using the upper end of this cost scale results in a BST cost of approximately $50.00 CDN per cow per year. The upper end of this production cost range is used in this study to include any additional charges for marketing, distribution and manufacturers profit.

3.3 Adoption Rates

In attempting to measure the aggregate level economic effects of a new technology on an industry an assumption is required on the rate of adoption by existing producers. With BST this is difficult as there is no previous data on the commercial acceptance of this product. Survey studies in New York State (Kalter et al, 1985) and California (Zepada, 1989) yield some information but as in all polls they are subject to error. The New York poll showed a willingness by producers to try BST of 66% in 1 year and 85% over 5 years. The California study found 43% of producers polled would not be willing to try BST.

Table 3.3 outlines the adoption rates based on these studies, discussion with industry experts and a reading of the literature, were chosen for this study. As previously outlined in chapter 2 the rate of adoption for a new technology is generally a function of a firm's size, the profitability of the technology, the proportion of firms who have already adopted it, the level of investment required and other variables (Mansfield, 1968; Coombs et al, 1987). Available data which is useful for developing assumptions on rates of adoption are average provincial yields and the distribution of farm herd sizes within each province. Two sets of adoption rates are calculated, one based

Table 3.3 Projected Adoption Rates of BST, by province based on average yields (Criterion A) and herd size (Criterion B)

Province	Large	Medium	Small	Total
	(------------------	%	----------------	)
British Columbia				
Criterion A	75	65	55	68.4
Criterion B	65	55	45	58
Alberta				
Criterion A	52.5	42.5	32.5	45.1
Criterion B	65	55	45	58
Saskatchewan				
Criterion A	43.5	33.5	23.5	32.8
Criterion B	65	55	43	54
Manitoba				
Criterion A	51	41	31	38.2
Criterion B	65	55	43	52
Ontario				
Criterion A	63.5	53.5	43.5	49.9
Criterion B	65	55	43	51
Quebec				
Criterion A	62.5	52.5	42.5	46.2
Criterion B	65	55	43	49
Maritimes				
Criterion A	64	54	44	54.3
Criterion B	65	55	45	55
Canada				
Criterion A	60.9	51.4	41.8	48.1
Criterion B	65	55	45	52.0

on each of these criteria. This procedure is followed based on discussion with industry experts. The choice of two different measurements downplays the significance of the regional differences based on a single criteria. It reduces the risk of reporting unreasonable results based on a single assumptiom.

The first set of adoption rates outlined in Table 3.3 are based on average provincial milk yields (Criterion A). These yields are used as a proxy for dairy farm profitability. Based on personal communication with specialists in the industry the rates chosen for B.C. were as follows: 75% for large farms (> 77 cows), 65% for medium size (48 - 77 cows) and 55% for small operations (< 48 cows). Based on weights for the proportion of cows in each category (Statistics Canada Cat. # 96-102) an overall adoption rate of 68% for B.C.dairy farms resulted. Farms with under 18 cows were not included in these calculations.

The B.C. dairy industry is characterized by having both the largest average herd size and the highest average yields per cow of any of the provinces. It is therefore assumed that B.C. has the highest provincial adoption rate. The rates for the other provinces are adjusted downwards with criterion A based on the percentage that their yields are lower than these yields in British Columbia.

The second set of adoption rates in table 3.3 (criterion B), is based on provincial farm herd size distributions. Categories for herd size are the same as for criterion A with the large farms having an adoption rate of 65%, medium size farms 55% and the small farms 45%. These rates are held constant across each province and multiplied by the proportion of animals in each classification.

Using the first criterion the adoption rates ranged from a low of 33% in Saskatchewan to a high of 68% in British Columbia. This national average adoption rate is 48%. Under criterion B the lowest rate is in Quebec at 49% and up to 58% in British Columbia. This results in a national average of 52%.

These assumed rates represent a medium term time horizon implying that over five years dairy farmers will adopt this new technology at these rates. The results presented in chapter 5 are sensitive to these chosen adoption rates and should be interpreted within this context.

3.4 Summary

In summary, this chapter has presented information on a large full lactational experiment on the efficacy and safety of BST for dairy cows. The biological data specific to BST, the assumed cost of BST and the rates of adoption assumed for each province were presented.

Chapter 4

The Empirical Model

The purpose of this chapter is to detail the empirical model developed in this thesis. A brief introduction to the Canadian Regional Agricultural Model (CRAM) (Webber et al, 1986) is first presented followed by more detail on the production, processing, shipping and demand subsectors of the dairy sector in this model. Those dairy subsectors will first be described conceptually, detailing the main structural components of the model, and then empirical details of the model and the data requirements are noted.

4.1 Overview of CRAM

CRAM is a regional-level mathematical programming model of the Canadian agricultural industry. The major production activities and final demands linked by transportation between regions and with the rest of the world are all modelled making CRAM a sector-wide model. Originally, a single period model with base year 1984 it has been updated to a 1986 base.

Briefly, the CRAM modelling system (Graham et al, 1989) is composed of:

1) A set of data files that contain region specific resource, production and demand information;

2) A fortran matrix generator which has the flexibility of

generating linear programming matrices with different structures depending on the nature of the problem being tackled;

3) An optimizing or simulating feature;

4) A report writer that helps to interpret output; and

5) A set of spreadsheets that generate the comparative statics information that is reported.

The underlying strength of the model is the specification of production responses at the regional level and the linking of output with provincial demand and world markets through a transportation matrix.

It is a multicommodity, multiregion programming model. The model represents Canada's agricultural sector with 29 crop regions producing wheat (4 grades), barley and other coarse grains, flax, canola, corn, soybeans, hay, pasture and other crops. Livestock production is modelled at the provincial level for beef, dairy, hogs and poultry. Shipments of livestock, livestock products and grains occur to meet provincial demand levels, with excess domestic demand or supply being met by import or export activities. Demand for beef, pork and grains are endogenized using stepped functions. Opening inventories of livestock are adjusted through incorporation of retention functions responding to own price, feed grain price and other effects. Trade requires that export and import prices be established; a domestic floor and ceiling price is specified. A small country assumption is adopted which means that Canadian trade will not affect world prices. The following summary provides some additional features of the model.

Model Characteristics:

- Static, spatial, partial equilibrium linear programming model focused upon the major agricultural sectors.

- Contains 5 major geographical levels - national; east and west; provincial (combining the maritime provinces); crop region, and export or shipping points.

- Contains 29 crop regions - 22 in the Prairies and one for each of the remaining provinces.

- Grains, oilseeds, dairy, beef, pork, eggs,and poultry are included. Fruit and vegetables are excluded.

- Fairly detailed production input relationships are included in the model, allowing examination of both the direct and indirect effects of changes in government policy.

- Unit costs, opening grain stocks, livestock inventories, and certain import and export levels are exogenously specified.

- Models supply and demand relationships for all major commodities.

- Uses assumed elasticities of supply and demand, based on literature searches, which represent the expected responsiveness of supply/demand to price changes.

- Shipments of livestock, livestock products and grains occur to meet provincial demand levels, with excess demand/supply met by import/export activities.

- Trade activities respond to export and import prices, specified in the model as domestic floor and ceiling prices.

- The model assumes Canadian trade will not affect world or North American prices.

The Crop Block:

- Crops modelled include wheat (4 grades), barley (including other coarse grains), flax, canola, corn, soybeans, hay, pasture and other crops.

- The model permits choice among the various crops, given the constraints of soil and climate on yield.

- Choice also occurs between grain crops, hay, pasture and fallow (using a set of fallow ratios).

- Crop rotations are very important, since yields will vary when lanted on fallow vs. stubble..Crops are grown in 29 geographic regions, differentiated primarily by soil and climatic zones.

- Crops produced in these regions are transferred to the provincial level to meet the demand for livestock feed and domestic consumption, or transferred to port for export.

The Livestock Block:

- Beef, pork and dairy production activities are modelled in detail, while the poultry sector is modelled as single activities for each of broiler, egg and turkey production.

- Diets are expressed in terms of stored forage, pasture and barley for beef and dairy animals; barley for hogs; and wheat for poultry. Protein supplement feeding is not accounted for at this time. Grains input substitution is possible.

- Opening stocks, input requirements (including diet and cash costs), and replacement ratios are all specified to determine yield, closing stocks and price.

- Livestock inventories, prices and government payments are set at 1986 levels, and the demand functions are calibrated to replicate prices and consumption in that year.
- Livestock inventory retention functions specified are based on econometrically estimated relationships.

Government Programs:

- Expected payouts under each of the various programs are used to supplement market returns.

- Programs explicitly modelled are:
  - Western Grain Stabilization Act
  - Agricultural Stabilization Act
  - Crop Insurance
  - Federal and Provincial Red Meat Stabilization Programs
  - Two Price Wheat Program
  - Input Subsidies
  - Special Canadian Grains Program
  - Western Grains Transportation Act
  - Dairy levies and subsidies
  - Feed Freight Assistance

- The benefits of supply management for the dairy and poultry sectors are captured.

- The model assumes farmers view government payments as equivalent to market receipts.

This section has given a brief outline of the CRAM model. In the next section the dairy subsector of the CRAM model will be discussed in much more detail, including the production, processing, trade and demand subsectors.

4.2 Dairy Sector in CRAM - Conceptual

The general structure of the dairy industry model, as specified in CRAM, is based on the approach followed by Short and Cote (1986). The model balances butterfat (FAT) and solid-not-fat (SNF) from milk supplies with the demands of these milk components as specified by national level demand functions for the final dairy products. It is a national level model and assumes supplies of fresh milk, industrial milk and industrial cream are fixed. In CRAM milk is supplied from a provincial level production subsector given the opening stock number of dairy cows in each province. Milk produced is shipped to provincial dairy processing subsectors where it is divided between the fluid and industrial markets. Balance equations similar to those used by Short and Cote split the raw milk into FAT and SNF which is used to manufacture seven final dairy products: whole milk, low fat milk, creams, cheese, skim milk powder and other dairy products. The processed products then move through to that demand sub-sector net of any interprovincial or international trade. In the sections that follow details of the production, processing, trade and demand subsectors are presented.

4.2.1 Dairy Production Subsector

The basic supply of raw milk for the dairy processing and marketing activities in CRAM is from farms specified in the dairy production subsector of the model. These production activities are provincial-level with three categories of dairy animals being specified and fed combinations of pasture, forage and barley.

The general equations for this subsector of the model may be grouped into eleven sets of equations which are specified for each provincial producing region in the model, ie for each province:

(1) Provincial Cash Costs

O/S of cows, heifers and calves times cash costs per animal of each	+	Number veal animals fed times cash costs per animal	-	Provincial dairy production sector cash costs	≤ 0

(2) Provincial Crop Balances

O/S of cows, heifers and calves times the forage, pasture, and barley usage per animal of each category	+	Number veal animals fed times barley usage per animal	-	provincial feed usage by dairy production sector	≤ 0

(3) Opening Stocks

O/S of cows heifers and dairy calves	≤	RHS numbers of cows heifers and dairy calves

Note: If long run retention function option is specified O/S numbers may increase or decrease by a calculated coefficient.

(4) Dairy Balances

	O/S of cows adjusted for culling and death loss	-	O/S Heifers adjusted for death loss	-	Culled heifers	+	C/S of cows			≤ 0
-	number calves produced by O/S	-	number calves produced by O/S heifers	+	C/S dairy calves	+	Veal animals fed	+	Transfer of calves to beef sector	≤ 0
-	Calf O/S numbers for death loss	+	Heifers killed	+	C/S heifers					≤ 0

(5) Closing Stocks

-	C/S numbers of cows, heifers and dairy calves	+	Retention function activities for cows, heifers and calves	≤ 0

(6) Dairy Slaughter

Dairy calf, heifer and cow slaughters	-	Bounded activities for net provincial (beef and dairy) animal slaughter	≤ 0

(7) Yield/Demand Transfer

-	O/S numbers of cows times LQ beef and milk yields and yields from slaughters (calves, heifers, veal) times slaughter numbers	+	Quantities demanded for beef and veal (net of trade) and amount of milk processed products demanded (net of trade)	≤ 0

(8) Retention Functions

O/S Numbers of dairy cows, heifers and calves	-	Retention activity numbers of cows, heifers and calves times coefficients adjusted for changing herd size for different arguments	≤ 0

(9) Input Accounting

O/S numbers of cows, heifers and calves times coefficients for costs and feed use	-	Activities to account for provincial cash costs and and feed use	≤ 0

(12) Yield Accounting

O/S cows and slaughters of heifers and calves times yields milk and HQ and LQ beef	-	Activities to account for provincial yields of milk, HQ and LQ beef	≤ 0

(11) Government Payments

O/S numbers of - cows, heifers and calves times payment/ animal	+	Provincial government payment to dairy activity	≤ 0

In this section an explanation for each of the equation in the model follows:

Cash costs and feed accounting activities for pasture, stored forage and barley (through provincial crop balance rows) are defined and these are associated with opening stock activities on cows, heifers and calves (equations 1 and 2). The veal activity draws from a calf balance row and includes activities for cash production costs and the provincial barley balance row.

The herd size for each province is set by specifying right hand sides on opening stock numbers for the cow, heifer and calf categories (equation 3). Balance rows for these three categories determine how opening stock numbers are accounted for or transferred through the time period to other categories in the provincial herd. A typical herd transfer equation is followed in which opening stocks + purchases + transfers in are greater than or equal to closing stocks + sales + transfers out. This includes adjustments for loss due to natural death rates and culling of the various categories, as well as allocating calves to veal feeding, transfers to the beef sector, or rejoining the dairy herd as heifers (equations 4, 5 and 6).

Milk production is associated with the opening stock of dairy cows (equation 7). A provincial yield row accounts for total milk production and is used to transfer this milk to the processing sector where it is allocated between the fluid and industrial markets.

Aside from milk three types of byproducts from the dairy herd are produced in the dairy production sector. High quality (HQ) and low quality (LQ) beef results from slaughter and culling activities of cows, heifers and calves. These are aggregated, along with HQ and LQ beef from the beef sector, into provincial beef production accounting rows, which transfer these outputs to the demand sector. A number of the dairy calves also transfer into the production of veal. This enters a national yield row along with the veal produced in the other provinces.

The model allows for herd size changes through the use of retention functions (equation 8). The retention rows allow for a ratio of the closing stock numbers to the opening stock to simulate responses to changing arguments for this function such as own price, feed price or other important variables. Current prices, expected future prices and an estimate of the associated elasticity are required to calculate the coefficients for this function (Graham et al, 1988). For long run analysis the opening stock activities use these coefficients to increase or decrease opening stocks. Closing stock numbers are equated to these assuming a long run situation.

The input accounting rows are used to keep track of the dairy herd's cash costs and feed use. Likewise, yield accounting rows are used to tally the dairy herd contribution of LQ and HQ beef to the provincial totals, and the supply of raw milk to the processing sector (equations 9 and 10).

There are rows that account for government payments to the provincial dairy sectors (equation 11). Currently the subsidy payments, as well as levies are calculated on milk as it enters the processing subsector.

Figure 4.1 details the matrix for the dairy processing subsector. Activities are represented by the columns in this matrix and the constraints by the rows. The first group of columns are the opening stocks of the three principal categories of dairy animals. Coefficients for these activities draw from the cash production cost row and for feed from the provincial crop balance

			Provincial Dairy Production Sector												Retention Functions			Accounting Activities							
			Opening Stocks					Closing Stocks																	
			Cows	Heifers	Calves	Kill Heifers	Kill Calves	Cows	Heifers	Calves	Feed Veal	Dairy Calf Slaughter	Calf Transfer	Prov. Gov't. Pmt.	Cows	Heifers	Calves	Cash Costs	Forage	Pasture	Barley	HQ Beef	LQ Beef	Milk	Right Hand Side
		UNITS	Head											$	Head			$ tonnes bu tonnes thous Hl							
Provincial Cash Costs		dollars	a	a	a						a														≤ 0
Provincial Crop Balance	Forage	tonnes	a	a	a																				≤ 0
	Pasture	"	a	a	a																				≤ 0
	Barley	bu	a	a	a						a														≤ 0
Opening Stocks	Cows	head	a																						≤ Dairy Opening Stocks
	Heifers	"		a																					
	Calves	"			a																				
Balances	Cow	head	$\bar{a}$	$\bar{a}$		1		1																	≤ 0
	Calf	"	$\bar{a}$	$\bar{a}$						1	1		1												≤ 0
	Heifer	"			$\bar{a}$		1		1																≤ 0
	Cull heifers	head		$\bar{a}$		1																			≤ 0
Closing Stocks	Cows	head						$\bar{1}$							1										≤ 0
	Heifers	"							$\bar{1}$							1									≤ 0
	Calves	"								$\bar{1}$							1								≤ 0
Dairy Slaughter	Dairy calf	head									$\bar{1}$	1													≤ 0
	Heifer/steer	"				1	1																		≤ 0
	Cow/bull	"	a																						≤ 0
Transfers to Demand	HQ Beef	tonnes				$\bar{a}$	$\bar{a}$																		≤ 0
	LQ Beef	"	$\bar{a}$			$\bar{a}$	$\bar{a}$																		≤ 0
	Raw milk	thous Hl	$\bar{a}$																						≤ 0
	Cdn. veal	tonnes										$\bar{a}$													≤ 0
	Dairy calf slaughter	head										1													≤ 0
	Beef calf balance	"											$\bar{1}$												≤ 0
Retention Functions	Cows	head	1												$\bar{a}$										≤ 0
	Heifers	"		1												$\bar{a}$									≤ 0
	Calves	"			1												$\bar{a}$								≤ 0
Input Accounting Rows	Cash costs	dollars	a	a	a													$\bar{1}$							≤ 0
	Forage	tonnes	a	a	a														$\bar{1}$						≤ 0
	Pasture	"	a	a	a															$\bar{1}$					≤ 0
	Barley	bu	a	a	a																$\bar{1}$				≤ 0
Yield Accounting Rows	HQ Beef	tonnes				a	a															$\bar{1}$			≤ 0
	LQ Beef	"	a			a	a																$\bar{1}$		≤ 0
	Raw milk	thous Hl	a																					$\bar{1}$	≤ 0
Provincial Gov't. Payments		dollars	$\bar{a}$	$\bar{a}$	$\bar{a}$									1											≤ 0
Federal Gov't. Payments		"												1											≤ 0

Figure 4.1: Provincial Dairy Production Submatrix

rows. The yields of milk and byproducts from this subsector supplied from these opening stock activities into yield rows which are then balanced with domestic and foreign demands. Demand is always less than or equal to supply.

The allocation of the opening stock numbers is controlled by coefficients relating the activities for opening stocks, closing stocks and slaughter to opening and closing stock rows, balance rows and slaughter rows. The retention function activities and rows allow for herd size changes as explained previously.

The final set of activities in Figure 4.1 are accounting activities. These simply tally provincial input use, yields and government payments through accounting rows which are associated with opening stock and culling activities.

4.2.2 Dairy Processing Subsector

Raw milk produced at a provincial level is transferred via the yield row to a provincial dairy processing subsector. Raw milk is split into the fluid and industrial needs, proceessed into fresh milk and the industrial use is manufactured into final products. Products specified include: lowfat and whole milk, fluid cream, cheese, butter, skim milk powder and other dairy products. The general equations for this sector are:

(12) Provincial Cash Costs

Processing costs	+	Levies	-	Subsidies	-	Provincial dairy processing sector cash costs	≤ 0

(13) Processing Costs

Activity for processing dairy product times unit processing cost	-	Total provincial processing costs	≤ 0

(14) Levies

Fluid market milk production times skim-off levy	+	Industrial market milk production times in-quota levy	+	Over quota milk production times over quota levy	-	Provincial levy total	≤ 0

(15) Subsidy

- Industrial market milk production times subsidy	-	Industrial cream production times subsidy	+	Provincial subsidy total	≤ 0

(16) Milk Balance

Fluid market milk production	+	Industrial market milk production	+	Overquota milk production	+	Industrial cream production	-	Total provincial supply raw milk	≤ 0

(17) Fluid:Industrial Ratio

Fluid market milk production	-	Industrial milk (including overquota) production times proportion of total which goes to industrial	≤ 0

(18) <u>Industrial Cream Ratio</u>

Total raw milk production	-	Industrial cream production times proportion of production which goes to cream production	≤ 0

(19) <u>Market Share Quota</u>

Industrial market milk production times amount of butterfat per hectolitre	+	Industrial Cream production times amount butterfat per hectolitre	$\leq$	Provincial MSQ level in tonnes butterfat

(20) <u>Milk Component Balances</u>

(a) Fluid Butterfat

-	Fluid Market Milk Production times amount butterfat per unit (Hl)	+	Transfer (tonnes) of butterfat to industrial market	+	Production of fluid market final products times amount of butterfat per unit	≤ 0

(b) Fluid Solid Non Fat

-	Fluid market milk production times amount of SNF per unit (Hl)	+	Production of fluid market final products times amount SNF per unit (Hl)	≤ 0

(c) Industrial Butterfat

-	Industrial Milk Production times amount butterfat per unit (Hl)	-	Over Quota milk production times amount butterfat per unit (Hl)	-	Industrial cream production times amount butterfat per unit (Hl)	+	Production of industrial market final products times amount butterfat per unit (Hl)	≤ 0

(d) Industrial Solid Nonfat

- Industrial milk production times amount SNF per unit (Hl)	- Over quota milk production times amount SNF per unit (Hl)	- Industrial milk production times amount SNF per unit (Hl)	+ Production of industrial market final products times amount SNF per unit (Hl)	≤ 0

Associated with the processing activities are processing costs (equation 13). These costs are summed up and transferred to the provincial cost row, which in turn negatively enters the objective function (via equation 12).

The butterfat subsidy along with the skim-off, in-quota and overquota levies are associated with activities for the four basic milk supplies (equations 14 and 15). These equations represent part of the government policy component of the model. The fluid market milk has a skim-off levy to cover the movements of butterfat to the industrial sector. The industrial milk (within MSQ) is charged an in-quota levy, but receives the butterfat subsidy. Over-quota milk production is charged an over-quota levy. And, finally, industrial cream receives the butterfat subsidy but is not charged a levy.

In the milk balance equation (equation 16), raw milk from the production sector is allocated to one of four uses, fluid market milk, industrial market milk, overquota milk and industrial cream. A ratio of fluid to industrial (per province) ensures the fluid quota levels as set by the CDC for each province are not exceeded (equation 17). The remainder of the milk, after fluid use is accounted for, is allocated to one of the three industrial uses.

The industrial cream supply is also controlled through the use of a ratio on total milk production (equation 18). This, along with the remaining milk in a province, draws from the row for market share quota (equation 19). Once the MSQ is totally used for a province excess production is allocated to overquota milk. This overquota production is charged a large levy. A milk balance row insures these four activities use all raw milk supply for a given province (ie: total use $\leq$ total supply).

Different supplies of milk are broken down into their butterfat and SNF components in the four milk component balance rows (equations 20 a,b,c and d). Fluid milk components enter the fluid balance rows and industrial supplies enter the industrial balances. On the demand side the final products draw from their respective market balance rows. This ensures the amounts of butterfat and SNF used by the fluid or industrial products don't exceed the amounts available given the supplies of milk.

The CRAM submatrix which is described by these equations is shown in Figure 4.2. The first group of activities represent the milk allocation activities. The total supply of milk and the four allocations of this total supply are included in this group. The total supply of milk is allocated to one of these uses through the ratio rows. Subsidy and levies are accounted for by coefficients on these activities and the subsidy or levy row. MSQ is read off of the industrial milk and cream activities into an MSQ row. Any additional industrial market milk in excess of this MSQ constraint

		UNITS	Milk Allocations: Milk Supply	Fluid	Industrial	Overquota	Cream	Transfers: Fat	Proc. Cost	Levy	Subsidy	Processing Activities: Standard Milk	Lowfat Milk	Cream	Cheese	Butter	Skim Milk Powder	Other Products	RIGHT HAND SIDE
			thous Hl	thous Hl				tonnes	dollars			thous Hl			tonnes				
Provincial	Cash Costs	dollars							1	1	$\bar{1}$								≤ 0
	Processing Costs	dollars		a	a	a			$\bar{1}$			a	a	a	a	a	a	a	≤ 0
	Levy	"			$\bar{a}$		$\bar{a}$			$\bar{1}$									≤ 0
	Subsidy	"									1								≤ 0
	Raw Milk Supply	thous Hl	1																≤ 0
	Milk Balance	"	$\bar{1}$	1	1	1	1												≤ 0
Ratios	Fluid Industrial	thous Hl		1	$\bar{a}$	$\bar{a}$													≤ 0
	Skim-Off Cream	"	1				$\bar{a}$												≤ 0
	Market Share Quota	tonnes			a		a												≤ 0 (Provincial MSQ)
Milk Component Balances	Fluid Mkt Fat	tonnes		$\bar{a}$				1				a	a	a					≤ 0
	Fluid Mkt SMF	"		$\bar{a}$								a	a	a					≤ 0
	Indust. Mkt Fat	"			$\bar{a}$	$\bar{a}$	$\bar{a}$	$\bar{1}$							a	a	a	a	≤ 0
	Indust. Mkt SMF	"			$\bar{a}$	$\bar{a}$	$\bar{a}$								a	a	a	a	≤ 0
Transfers to Demand Sector	Standard Milk	thous Hl										$\bar{1}$							≤ 0
	Lowfat Milk	"											$\bar{1}$						≤ 0
	Cream	"												$\bar{1}$					≤ 0
	Cheese	tonnes													$\bar{1}$				≤ 0
	Butter	"														$\bar{1}$			≤ 0
	Skim Milk Powder	"															$\bar{1}$		≤ 0
	Other Products	"																$\bar{1}$	≤ 0

Figure 4.2: Provincial Dairy Processing Submatrix

goes into the overquota activity where it is charged the overquota levy. The activity for fluid (fresh) milk supplies balance rows for fluid FAT and SNF. The industrial milk, overquota milk and industrial cream supply the industrial FAT and SNF rows.

The second set of activities in Figure 4.2 are the transfer activities. The FAT transfer activity transfers any butterfat not required to manufacture fluid market final products to the industrial FAT constraint row. The transfer activities for processing costs, subsidy and levies transfer these amounts to the provincial cash cost row where they enter the objective function.

The final set of activities in Figure 4.2 are the processing activities. All of the final dairy products draw from the associated FAT and SNF rows. Processing costs are accounted for in the proceeing cost row. Final products are then transferred to the shipping and marketing subsectors via the transfer rows.

4.2.3 Dairy Trade Block

Only industrial milk products are shipped in the CRAM model. These may be shipped either interprovincially or internationally. The equations for this sector are:

(21) National Transport Costs

Interprovincial movements of product times shipping cost per unit	+	Province - World trade movements times the shipping cost per unit	-	Total Shipping costs for the given product	≤ 0

(22) Demand Transfers

Exports of product from province	-	Imports of product into province	≤ 0

(23) Provincial Trade Accounting

Imports to province (exports from province)	-	Total provincial imports (exports)	≤ 0

(24) Canadian Exports

-	Summation of province to world movements of product	+	Total Canadian exports of product	≤ 0

(25) Canadian Imports

Summation of world to province movements of product	-	Total Canadian imports of product	≤ 0

Only industrial dairy products in this study are shipped either interprovincially or internationally in the CRAM model, however the model structure also allows fluid milk movements. Any imports are added to supplies and exports drawn from the demand transfer row ensuring only production for domestic consumption goes through to the demand subsector (equation 22). These movements also enter accounting rows to track provincial imports and exports (equation 23).

Total exports from each province to the world and imports to each province from the world are tallied in a Canadian export row and a Canadian import row (equations 24 and 25). These totals are then transferred up to the objective function row where the value of the imports enter as a cost and the value of the exports a revenue.

The general CRAM submatrix for dairy trade is shown in Figure 4.3. Interprovincial trade activities are supplied by provincial export rows and transfer to import rows. These activities, as well as the other trade activities have costs associated with them accounted for in the national transportation cost row.

International trade activities are the same as interprovincial except that Canadian exports negatively enter an export accounting row and Canadian imports are accounted for in a Canadian import row. These rows are transferred directly to the objective rows via activities for Canadian exports and imports. Trade accounting activities tally provincial totals of imports and exports.

4.2.4 Dairy Demand Subsector

The processed dairy products, net of trade, supply domestic demand functions specified on a regional level for western or eastern Canada. The regional demands are split down to the provincial level by the use of ratios representing a provinces share in regional demand. The general equations for this subsector are:

	Interprov-incial Trade				Provincial-World Trade						Inter-nat'l Trade		Trade Accounting Activities						RIGHT HAND SIDE
	B.C. to Alta	Alta to B.C.	Alta to Sask	Sask to Alta	B.C. to World	Alta to World	Sask to World	World to B.C.	World to Alta	World to Sask	Canadian Exports	Canadian Imports	B.C. Imports	B.C. Exports	Alta Imports	Alta Exports	Sask Imports	Sask Exports	
Objective Function											c	$\bar{c}$							Maximize
National Transportation Costs	a	a	a	a	a	a	a	a	a	a									≤ 0
British Columbia Transfer to Demand	1	$\bar{1}$			1			$\bar{1}$											≤ 0
British Columbia Imports		1						1					$\bar{1}$						≤ 0
British Columbia Exports	1				1									$\bar{1}$					≤ 0
Alberta Transfer to Demand	$\bar{1}$	1	1	$\bar{1}$		1			$\bar{1}$										≤ 0
Alberta Imports	1			1					1						$\bar{1}$				≤ 0
Alberta Exports		1	1			1										$\bar{1}$			≤ 0
Sask-atchewan Transfer to Demand			$\bar{1}$	1			1			$\bar{1}$									≤ 0
Sask-atchewan Imports			1							1							$\bar{1}$		≤ 0
Sask-atchewan Exports				1			1											$\bar{1}$	≤ 0
National Trade Balance					$\bar{1}$	$\bar{1}$	$\bar{1}$	1	1	1									≤ 0
Canadian Exports					$\bar{1}$	$\bar{1}$	$\bar{1}$				1								≤ 0
Canadian Imports								1	1	1		$\bar{1}$							≤ 0

Figure 4.3: Select Portion of Dairy Product Trade Submatrix

(26) Objective Function

Maximize:

Area under demand curve corresponding to step chosen for west	+	Area under demand curve corresponding to step chosen for east	-	Production costs

(27) Revenue (Price) Accounting Row

Revenue (price) associated with demand function step times 1 if step chosen and times 0 otherwise	-	Activity for revenue (price) of product	≤ 0

(28) Demand Row

Summation of production from provinces making up region	+	Net eastern or western demands associated with step times 1 if step chosen, times 0 otherwise	≤ 0

(29) Covexity Constraint

1 times activity of choosing step	-	Activity representing amount which consecutive steps most add up to in value	≤ 0

Using Duloy and Norton (1975) type demand functions the activity associated with a step on the demand curve which maximizes consumer plus producer surplus will be chosen. A convexity constraint ensures that only one step will be chosen, or some combination of two adjacent steps which add to one (equation 29). Accounting rows keep track of the revenue, price and quantity demanded for the chosen step (equations 27 and 28).

The CRAM submatrix for dairy product demand is shown in Figure 4.4. The activities representing provincial shares balance regional (eastern or western Canadian) demands with provincial supplies of final dairy products by allocating each provinces share of regional quantity demanded to a given provinces' supply.

The demand step activities each have associated with them a revenue, a price, a quantity demanded, a one in the convexity constraint and an objective function value. The convexity constraint rows are added up in the convexity actity which has a coefficient of ten thousand. This activity ensures only one step or a combination of two adjacent steps are chosen when the optimize routine is run and multiply the objective value by a factor of ten thousand.

The domestic demand curve for the dairy products which are traded internationally is shown in Figure 4.5. This portion of the demand curve is bounded from below by the export price. If supply on the domestic market exceeds Q^1 then the domestic price will remain at this price. It also has a price ceiling of the import price. If domestic supply were to be less than Q^0 the rest would be imports and the domestic price would be landed import price. Hence depending on supply a domestic price is determined.

		Provincial Share West	Provincial Share East	Western Demand Steps: Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Eastern Demand Steps: Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	Convexity Activity: WC	Convexity Activity: EC	RIGHT HAND SIDE
Objective Function				c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c	c			Maximize
Product Balances Transferred Processing Block	B.C.	a																								≤ 0
	Alberta	a																								≤ 0
	Sask.	a																								≤ 0
	Manitoba	a																								≤ 0
	Ontario		a																							≤ 0
	Quebec		a																							≤ 0
	Maritimes		a																							≤ 0
Western Demand Function Controls	Revenue			a	a	a	a	a	a	a	a	a	a													≤ 0
	Price			a	a	a	a	a	a	a	a	a	a													≤ 0
	Demand	$\bar{1}$		a	a	a	a	a	a	a	a	a	a													≤ 0
	Convexity			1	1	1	1	1	1	1	1	1	1											$\bar{a}$		≤ 0
Eastern Demand Function Controls	Revenue													a	a	a	a	a	a	a	a	a	a			≤ 0
	Price													a	a	a	a	a	a	a	a	a	a			≤ 0
	Demand		$\bar{1}$											a	a	a	a	a	a	a	a	a	a			≤ 0
	Convexity													1	1	1	1	1	1	1	1	1	1		$\bar{a}$	≤ 0

Figure 4.4: Demand Submatrix in CRAM

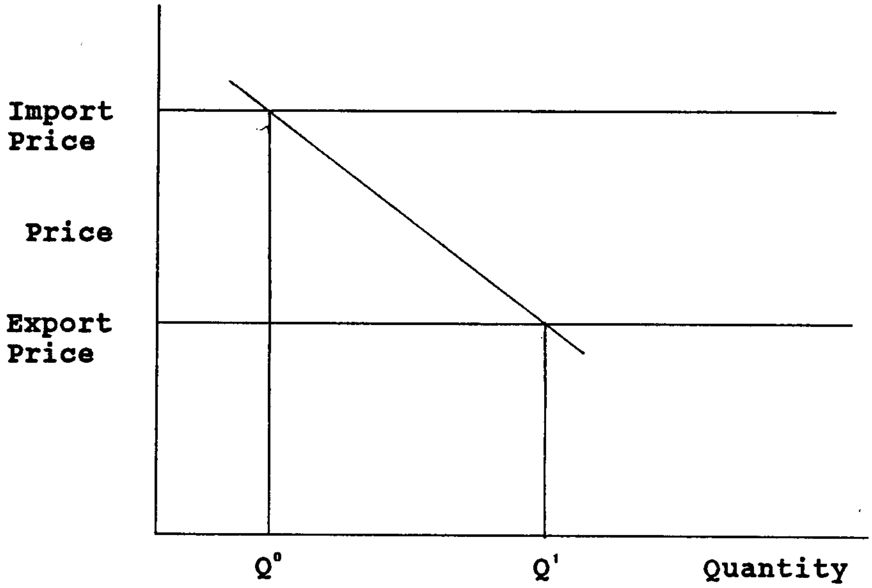

Figure 4.5: Domestic Demand Curve With Import and Export Prices

4.3 Matrix Coefficients

The following section of this chapter outlines the matrix coefficients in the dairy sector of CRAM. The basic format is the same as in section 4.2 detailing the data for the production, processing, trade and demand subsectors of the CRAM model.

4.3.1 Dairy Production Subsector

Provincial herd sizes and the average yields per cow assumed in this analysis are presented in Table 4.1. The yields are derived by dividing the provincial production (including industrial cream) by the number of dairy cows to arrive at a provincial average. These numbers are provided by Statistics Canada (Cat # 23-008).

Table 4.1: Provincial Dairy Herd Sizes, Supplies of Raw Milk and Yields, 1986

Province	Dairy Cow[a/] Numbers (000'head)	Replacement[a/] Heifers (000' head)	Milk[b/] Produced (000'hl)	Yield /cow (hl)
British Columbia	83	30	4,888	58.89
Alberta	130	44	5,897	45.36
Saskatchewan	59	16	2,244	38.03
Manitoba	71	27	2,913	41.03
Ontario	503	244	24,387	48.48
Quebec	615	251	28,401	46.18
Maritimes	86.4	36	4,320	50.00
Canada	1547.4	648	73,050	47.21

Source: [a/] Statistics Canada, Cat. No. 23-008, Nov. 1988.
[b/] Dairy Farmers of Canada, 1987

The dairy herd size also includes dairy calves. Cash costs and use of barley, pasture, and forage as well as the yields of beef as a byproduct associated with the dairy sector are presented in Table 4.2. These data form the coefficients or right hand sides of activities and rows associated with production activities in each of the provinces.

4.3.2 Dairy Processing Subsector

The coefficients used in the dairy processing subsector are categorized into three sets: ratios for the split of milk into fluid and industrial, representing a policy decision a set dealing with the different subsidies and levies, and information for the processing of milk into final dairy products (FAT and SNF contents, processing margins, etc.) . Three data files are used to specify these values for each provincial processing subsector. The breakdown of raw milk into the fluid and industrial milk supplies is given in Table 4.3.

In 1986 Canada produced a total of 73.05 million hectalitres of milk which was commercially sold (Dairy Farmers of Canada, 1987). Of this total production approximately 36% was produced for the fluid (fresh) milk market. The balance, 64%, was produced for the manufacturing of industrial milk products.

Table 4.2: Feed Use and Cash Costs for Provincial Dairy Production Regions, Per Animal, 1986

Province	Category	Cash Costs ($)	Barley (bu.)	Forage (tons)	Pasture (tons)	HQ Beef	LQ Beef	Veal
British Columbia	Cows	1398[a/]	44.09	1.42	0.58	0	576.3	0
	Replacements	270	16.70	0.88	0.44	513.7	0	0
	Heifer Calves	100	8.35	0.33	0.33	513.7	0	0
	Veal Calves	100	20.90	0	0	0	0	169.2
Alberta	Cows	1249	30.00	1.59	0.80	0	547.1	0
	Replacements	239	16.70	1.19	0.60	533.8	0	0
	Heifer Calves	100	8.35	0.33	0.33	533.8	0	0
	Veal Calves	100	20.90	0	0	0	0	151.1
Saskatchewan	Cows	1063	21.30	1.81	0.91	0	554.3	0
	Replacements	253	16.70	1.37	0.56	516.0	0	0
	Heifer Calves	100	8.35	0.33	0.33	516.0	0	0
	Veal Calves	100	20.90	0	0	0	0	149.6
Manitoba	Cows	987	27.60	1.59	0.80	0	532.0	0
	Replacements	253	16.70	1.19	0.60	515.1	0	0
	Heifer Calves	100	8.35	0.33	0.33	515.1	0	0
	Veal Calves	100	20.90	0	0	0	0	0
Ontario	Cows	1149	33.70	1.55	0.78	0	553.7	0
	Replacements	251	16.70	1.16	0.58	551.8	0	0
	Heifer Calves	100	8.30	0.33	0.33	551.8	0	0
	Veal Calves	100	20.90	0	0	0	0	202.0
Quebec	Cows	1096	33.20	1.48	0.74	0	513.2	0
	Replacements	234	16.70	1.10	0.55	524.3	0	0
	Heifer Calves	100	8.35	0.33	0.33	524.3	0	0
	Veal Calves	50	15.00	0	0	0	0	110.8
Maritimes	Cows	1356	39.01	1.33	0.66	0	531.7	0
	Replacements	238	16.70	1.00	0.50	500.9	0	0
	Heifer Calves	100	8.35	0.33	0.33	500.9	0	0
	Veal Calves	50	15.00	0	0	0	0	118.9

Source: CRAM data base, 1987

a/ This coefficient includes the cost of the mill run and meal portions of dairy ration (Canadian Livestock Feed Board Prices)

Table 4.3: Breakdown of Total Farm Supplies of Milk into Fluid and Industrial, by Province, 1986

Province	Total Milk Sales	Fluid Milk Sales	Industrial Milk Sales	Industrial Cream Sales	Ratio of Fluid/ Industrial	Ratio of Production/ Industrial Cream
	(-------	-------	000' -------	-------)		
British Columbia	4,888	3,119	1,760	10	1.77	488.8
Alberta	5,897	2,577	3,096	224	0.83	26.33
Saskatchewan	2,244	976	1,106	164	0.88	13.68
Manitoba	2,913	1,139	1,477	294	0.77	9.91
Ontario	24,387	9,950	13,462	951	0.74	25.64
Quebec	28,401	6,873	21,528	0	0.32	0
Maritimes	4,150	2,002	1,960	188	1.02	22.07
Canada	73,050	26,636	44,389	1,831	0.60	39.90

Source: Dairy Farmers of Canada, 1987.

At the center of the dairy processing model as defined by Short and Cote (1986) are the four balance equations for FAT and SNF in the fluid and industrial markets. The provincial level balance equations in this study are somewhat modified versions having fewer processed products and a single "sink" product known as other dairy products to nationally balance FAT and SNF.

1. Fluid Market:FAT

$$-3.6 \text{ FLM} + \text{TRAN} + 3.604 \text{ STRD} + 1.956 \text{ LFAT} + 15.72 \text{ FCRM} \leq 0$$

2. Fluid Market:SNF

$$-8.6 \text{ FLM} + 8.52 \text{ STRD} + 8.719 \text{ LFAT} + 6.142 \text{ FCRM} \leq 0$$

3. Industrial Market:FAT

$$-3.6\ INDM - 3.6\ OQM - 3.6\ INDC + .871\ CHZ + .82\ BTR + .007\ SMP + .2250\ TDP \leq 0$$

4. Industrial Market:SNF

$$-8.6\ FLM - 8.6\ OQM - .669\ INDC + .871\ CHZ + .126\ BTR + .965\ SMP + .78\ OTDP \leq 0$$

where:

FLM	=	Fluid Milk(thous hl)	
INDM	=	Industrial Milk	(thous hl)
OQM	=	Over Quota Milk	(thous hl)
INDC	=	Industrial Cream	(thous hl)
TRAN	=	Skim Off Fat Transfers	(tonnes)
STRD	=	Standard Milk	(thous hl)
LFAT	=	Low Fat Milk	(thous hl)
FCRM	=	Fluid Cream	(thous hl)
CHZ	=	Cheese	(tonnes)
BTR	=	Butter	(tonnes)
SMP	=	Skim Milk Powder	(tonnes)
OTDP	=	Other Dairy Products	(tonnes)

The coefficients used in these balance equations are the same as those used by Short and Cote with the exception of the butterfat coefficient on industrial milk which was changed from 3.7 tonnes butterfat per hectolitre to 3.6, and the coefficients on Other Dairy Products as in its current form it did not exist in the national level model.

The subsidy on butterfat for industrial milk and cream along with the skim-off levy for fluid milk, the in-quota levy on industrial milk and the over-quota levy are given in Table 4.4.

Table 4.4: Subsidies and Levies Associated with Canadian Dairy Program, 1986

Province	Butterfat[a/] Subsidy	Skim-Off Levy	In-Quota Levy	Over-Quota Levy
	$/hl			
B.C.	5.77	0.30	5.13	38.00
Alberta	5.69	0.30	5.13	38.00
Saskatchewan	5.68	0.30	5.13	38.00
Manitoba	5.99	0.30	5.13	38.00
Ontario	5.95	0.30	5.13	38.00
Quebec	6.09	0.30	5.13	38.00
Maritimes	6.70	0.30	5.13	38.00

Source: The Dairy Review, Statistics Canada, January 1987, except,
[a/] Maryse Cote, Commodity Coordination, Dairy Unit, Agriculture Canada

The final set of coefficients used in the dairy processing sub-sector are those associated with marketing margins on the different processed dairy products. For fluid products the only available prices were at the retail level so the margins are farm gate-retail margins. Wholesale pieces are available for industrial market products so farm gate-wholesale margins are used. These margins, as well as farm gate values and retail/wholesale prices, are given in Table 4.5.

Table 4.5: Farm Gate Values, Retail or Wholesale Prices and Marketing Margins for Processed Dairy Products Used in CRAM model, 1986

Produce	Farm Value	Price[a/]	Marketing[b/] Margin
Fluid Market:			
Standard Milk	50.45	98.13	47.68
Low fat Milk	42.64	98.13	55.49
Cream	104.47	247.10	142.63
Industrial Market:			
Cheese	3.90	5.05	1.15
Butter	4.57	4.97	0.40
Skim Milk Powder	2.46	2.95	0.49

Source: Prices from FARM data base.

a/ Retail price for fluid market products, wholesale price for industrial market products.

b/ Farm gate-Retail margin for fluid market products, farmgate-wholesale margin for industrial market products.

The farm gate values for these products are based on the shadow prices of FAT and SNF resulting from the current dairy program. Butter and skim-milk powder are essentially joint products of milk. The CDC guarantees a price to the processors on these two products through an offer-to-purchase program. An assumed processing margin (per hectolitre of milk) is also negotiated between the CDC and the processors. The value of the skim milk powder and butter which can be manufactured from a hectolitre of milk less the assumed processors' margin is taken as the farm gate value (prior to subsidies and levies) of industrial milk is. This system is shown in Figure 4.6.

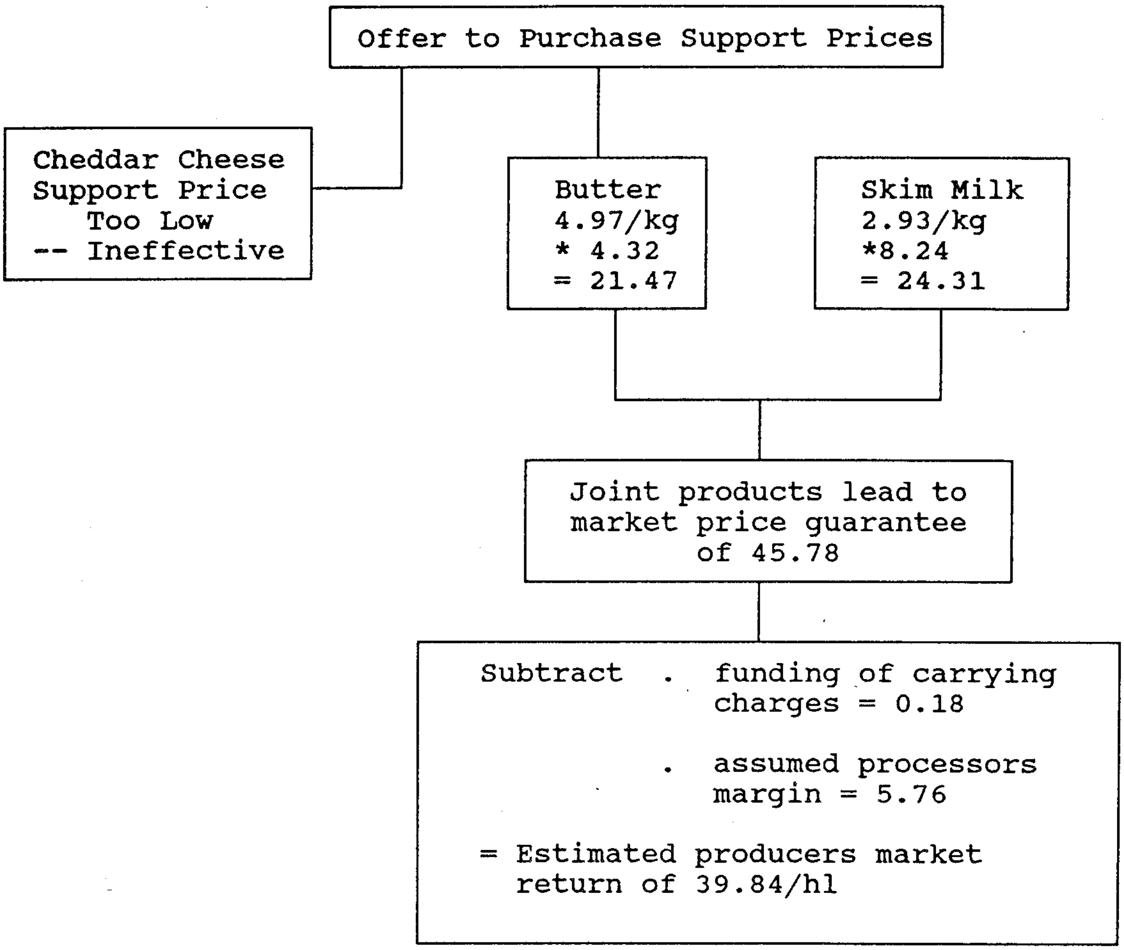

Figure 4.6 Calculation of producers market return based on offer to purchase scheme by CDC prior to subsidy and levy adjustments.

Source: Prices, Farm Model Database, 1986.
Based on Table 26, Dairy Facts and Figures at a Glance, Dairy Farmers of Canada, 1987

Based on the assumption that when milk is processed into these joint products 30, percent of the processing costs go to butter production and 70 percent to skim milk powder production, the farm gate value of these two products can be calculated. The calculations as shown below:

1 hl milk yields 4.32 kg butter

(.3)(5.76) = 1.728 of assumed processors margin to butter

1.728/4.32 = 0.40;

1 hl milk yields 8.24 kg skim milk powder

(.7)(5.76) = 4.032 of assumed processors margin to skim milk powder

4.032/8.24 = 0.49.

The processors margins on butter and skim milk powder are \$0.40/kg and \$0.49/kg respectively. If these are subtracted from the support prices the farm gate values are \$4.57/kg on butter and powder. A 2 x 2 linear program can be formulated with these farm gate values in the objective function and quantities of FAT and SNF in butter and skim milk powder as the constraints to calculate the shadow prices on these milk constituents under this policy. This L.P. is shown in Figure 4.7.

	Butter	Skim Milk Powder
OBJ	4.57	2.46
FAT	.8198	.007
SNF	.1264	.965

Figure 4.7: Linear program tableau to determine shadow prices on butterfat and solid not fat from industrial milk.

The solution of this LP yields a shadow price on FAT of \$5.19/kg and SNF of \$2.51/kg. Using these shadow prices and the amounts of FAT and SNF, in cheese, the farm value of cheese can be calculated, and thus the farm-gate wholesale margin (Table 4.5).

To calculate the shadow prices for the fluid market milk the assumption is made that the FAT component will have the same value in both markets. This assumption follows from the fact that there is surplus FAT in the fluid market from producing low fat fluid milks which is transferred to the industrial side. Once a value for FAT is determined it is quite simple to calculate the shadow price of SNF in the fluid market. Given a weighted average price of \$50.73 (Graham et al ,1989) for fluid milk the shadow price on SNF comes out to \$3.726/kg. Again, using the amounts of FAT and SNF in the fluid market products and these shadow prices the farm value and farm gate-retail margins can be calculated (Table 4.5).

4.3.3 Dairy Trade Block - Empirical

The transport rates to be used in the dairy trade subsector are based on shipping costs supplied by a contractor who hauls dairy products for one of the major cooperatives in BC. The total cost of shipping butter, skim milk powder and cheese to and from several Canadian cities was averaged to yield shipping costs per tonne per mile. All of these costs are based on 40,000 pound loads. The final values were, \$0.0564/tonne/mile for butter, \$0.0703/tonne/ mile for skim milk powder and \$0.0549/tonne/mile for cheese. The shipping costs are given in Table 4.6.

Table 4.6: Transport Costs for dairy products used in CRAM Model, 1986

Shipping Route	Distance (Miles)	Cheese	Butter	Skim Milk Powder
		(---------	$/tonne	----------)
B.C. to Alberta	650	35.70	36.70	45.70
B.C. to World	1,290	70.80	72.70	90.60
Alberta to B.C.	650	35.70	36.70	45.70
Alberta to Sask.	450	24.70	25.40	31.60
Alberta to World	1,860	102.10	104.90	130.70
Sask. to Alberta	450	24.70	25.40	31.60
Sask. to Manitoba	400	22.00	22.60	28.10
Sask. to World	2,200	120.80	124.10	154.70
Manitoba to Sask.	400	22.00	22.60	28.10
Manitoba to Ontario	1,300	71.40	73.30	91.40
Manitoba to World	2,570	141.10	145.00	180.70
Ontario to Manitoba	1,300	74.40	73.30	91.40
Ontario to Quebec	400	22.00	22.60	28.10
Ontario to World	500	27.50	28.20	35.20
Quebec to Ontario	400	22.00	22.60	28.10
Quebec to Maritimes	500	27.50	28.20	35.20
Quebec to World	360	19.90	20.50	25.60
Maritimes to Quebec	500	27.50	28.20	35.20
Maritimes to World	710	39.10	40.20	50.10

Source: Personal communication with Hauling Manager of a Major Cooperative in British Columbia

The shipping activities for exports to and imports from the world are measurements to a specified large urban centre in the United States. For the east the city chosen is New York and for the west Los Angeles.

4.3.4 Dairy Demand Subsector - Empirical

The prices used in the demand functions are given in Table 4.5. These prices are at the wholesale level for industrial products and the retail level for fluid market products. The domestic disappearances are given in Table 4.7 and the own price elasticities of demand are given in Table 4.8.

Table 4.7: Domestic Disappearances of Dairy Products Used in CRAM by Province, 1986 (Calendar Year)

Province	Standard Milk	Lowfat Milk	Cream	Cheese	Butter	Skim Milk Powder
	(------------- thous hl		-------------)	(----------- thous tonnes		-----------)
Western Canada	1926.6	5398.2	400.6	71623.1	24820.4	13145.7
British Columbia	847.7	1997.3	202.7	28649.2	11169.2	5126.8
Alberta	558.7	1889.4	112.2	23635.6	7694.3	4206.6
Saskatchewan	231.2	755.7	36.1	8594.8	2730.2	1840.4
Manitoba	289.0	755.7	48.1	10743.5	3226.7	1971.9
Eastern Canada	5634.1	12661.2	872.0	167901.8	74506.1	32184.3
Ontario	1915.6	7723.3	505.8	83950.9	41723.4	16042.2
Quebec	2817.1	3671.8	313.9	67160.7	16822.2	11908.2
Maritimes	901.5	1266.1	52.3	16790.2	5960.5	4184.0

Source: Fluid Disappearances, Dairy Market Review, 1986
Industrial Disappearances, Dairy Commodity Coordination Unit, Agriculture Canada

Table 4.8: Own Price Elasticities of Demand for Processed Dairy Products Used in CRAM model, 1986

Product	Elasticity
Fluid Market:	
Standard Milk	0.33
Low fat Milk	0.34
Cream	0.50
Industrial Market:	
Cheese	0.73
Butter	0.80
Skim Milk Powder	0.39

Source: FARM data base, 1986

4.6 Summary

In summary, this chapter has presented a model of the Canadian dairy industry including the production, processing, trade and marketing subsectors. The conceptual framework was presented first followed by a description of the coefficient requirements.

Chapter 5

Results

The purpose of this chapter is to present the results of the introduction of BST into the Canadian dairy industry based on the model assumptions noted earlier. This analysis compares a 1986 "base case" of the industry to several scenarios representing government policy alternatives.

The first scenario represents a "no policy change" situation. Current provincial quota levels, producer prices, levies and subsides remain unchanged in this scenario and it is assumed farmers adopt BST. Certain adoption rates are assumed for each province and the aggregate effects on supply, producer incomes and structural herd size adjustments are analyzed.

The second scenario attempts to predict the effect of BST on quota values. Representative farms in each province are assumed to adopt BST and the change in supply price and subsequent annual returns to quota are calculated. As in scenario 1 no change in dairy industry regulations are present.

The third scenario passes some of the benefits of BST adoption on to consumers. Instead of allowing producers to capture the expected benefits of BST adoption through increased quota values consumers will capture some of the benefits through lower prices. Production is increased until annual quota rents (farm-gate minus supply price) are equivalent to those in the base case levels.

The final scenario addressed will involve the benefits of BST adoption being passed on to the taxpayers. This is accomplished by decreasing the dairy subsidy at a national level by the amount that supply prices fall under scenario 1.

5.1 Base Case

The base case represents the status of the dairy industry in 1986 prior to any adjustments resulting from the introduction of BST. This solution is meant to represent the Canadian agricultural industry and more importantly for this thesis the dairy sector as it existed in 1986. This is presented to allow a comparison of scenarios representing government policy alternatives with the "status quo" situation.

Dairy herd sizes, that is, the mature dairy cows and replacement heifers by province, are outlined in Table 4.1 (Statistics Canada Cat# 23-008). Provincial milk yields and the yield per cow are also shown in this table (Dairy Farmers of Canada, 1987). Quebec and Ontario are important provinces in terms of the Canadian dairy industry. Quebec has 40% of the Canadian dairy cows while Ontario has 33%. Between these provinces they produce over 70% of the milk in Canada. Alberta is the third largest dairy producing province with just over 8% of Canada's total production. British Columbia has the highest average yield per cow at nearly 60 hl per year. This is a derived yield calculated by dividing commercial milk sales by the number of dairy cows in a province.

The allocation of raw milk supplies into the fluid market milk and the industrial milk and cream are shown in Table 4.3. Quebec produces the greatest percentage of industrial milk in Canada, producing nearly 50% of all industrial milk. The national average is 61%, implying that an average 61% of each provinces share of milk goes to the industrial market, while Quebec produces 76 percent. The largest producer of fluid market milk in Canada is Ontario with 33% of the national total. British Columbia has the highest percentage of fluid market milk production for a single province in Canada, producing 64% of it's total milk as fresh milk market.

The domestic disappearances of final processed dairy products for the base case, by province, are presented in Table 4.7. On the fluid side Quebec is the largest consumer of whole milk with 37% of the national total going to Quebec. Ontario consumes the largest quantity of lowfat milk with 43% of the national total. This high consumption of whole milk in Quebec, compared to the rest of Canada, is the only striking feature of these data.

5.2 Supply Prices and Quota Values

In order to be able to assess the impacts of BST on the Canadian dairy industry and the associated quota values one needs to know something about the supply functions of the supply managed dairy sector.

In Figure 5.1 the administratively controlled supply level is shown as Q_s, the supply price of producers is shown as P_s and the market price as P_m. Quota values in aggregate may be interpreted as a measure of the capitalized value of the economic rent created by restricting supply. These economic rents are represented by area P_mACP_s in Figure 5.1, while the per unit quota value is (Pm-Ps). The area P_mABP_e - BCD represents the increase in producers surplus resulting from the imposition of supply management.

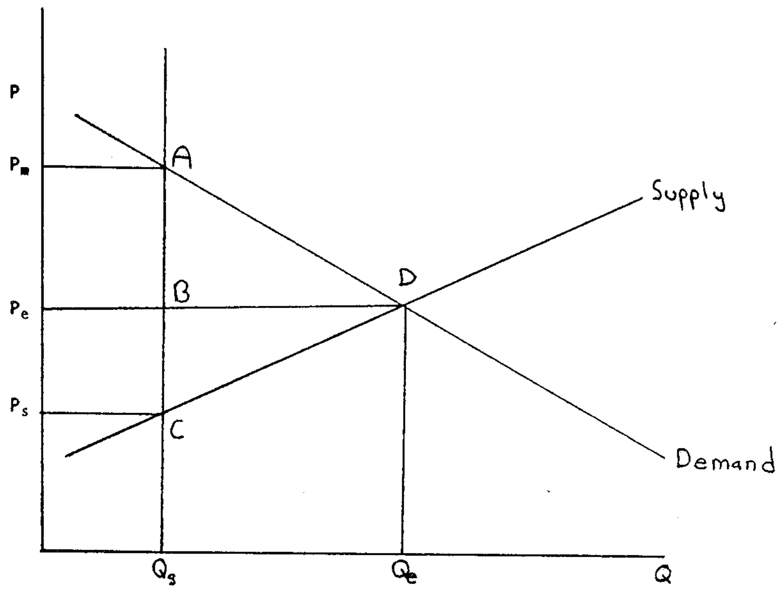

Figure 5.1: Producer Surplus Areas and Firm Rents Under Supply Management

Source: Graham et al, 1989

Forbes, Hughes and Warley (1982) and others have shown that the analysis is not quite as simple as the case presented. Transfer rules for quota may affect the cost of production, under-utilized fixed facilities may lead to very high quota values at the margin which would dissipate quickly with production increases, associated rents may already be capitalized into asset values, and risk reduction may have shifted the supply curve to the right. Although any or all of these may have a significant impact on current industry cost structure, available information to incorporate them into the analysis does not exist at this time.

The location of a firm's position on an industry supply curve may be estimated following procedures reported by Barichello (1984), Moschini and Meilke (1988), and others. This methodology involves using available information on the capital value of quota and an appropriate discount rate to determine the extent to which farm prices exceed marginal cost pricing at the restricted output level. The information on quota values in this study was obtained from Bollman (1988). Certain restrictions on transfer of quota exist and these vary substantially by province and interprovincial transfers of quota rights do not exist. This lack of reliable information on quota values is a short coming of this research. Attempts to validate the marginal cost pricing point used for this study were made by investigating information on cost of production and comparing these to estimated US producer prices.

Using the direct, unadjusted capitalization approach and a discount rate as shown in Table 5.1, the estimated supply price for dairy producers across the different provinces in Canada have been calculated (Graham et al, 1989). Product price differences between provinces are partly explained by the market regulations which allocate fresh and industrial milk market shares in differing

Table 5.1: Estimated Supply Prices for Milk Production in Canada, by Province, 1986

	Farm Gate Price ($/hl)	Quota Values ($/hl)	Estimated Discount Rate	Supply Price ($/hl)	% Diff.[a/]
B.C.	49.6	116.7	16.0	30.2	64
ALBERTA	41.9	47.3	14.1	34.8	21
SASKATCHEWAN	44.8	56.5	15.1	36.2	24
MANITOBA	42.5	65.7	15.0	32.6	30
ONTARIO	43.9	76.2	14.9	32.6	35
QUEBEC	40.3	64.2	13.5	31.6	27
MARITIMES	44.3	57.8	16.6	34.7	28
CANADA	42.3	69.7	13.5	32.6	31

[a/] Difference between supply price and farm gate returns

Source: Graham et al, 1989

proportions across provinces. Substantial differences in quota values between provinces are noted. Dairy producers in British Columbia, for example, have established a market equilibrium level for quota at $116.7/hl, while in Quebec the level is $64.2/hl.

It is estimated that the national supply price for producers at $32.6 per hectolitre is 31% below current market returns which average $42.3 per hectolitre. In Quebec this supply price is estimated to be $31.6 per hectolitre, the average market returns to producers are $40.3, and hence market returns are 27% above the supply price or marginal cost of production.

The discount rates are based on estimates by Moschini and Meilke (1988). The rates were calculated based on departures from marginal cost pricing in Ontario. The marginal cost estimates for the Ontario dairy industry were from an econometric cost function estimated with Ontario Dairy Farm Accounting Project data for the period 1978- 1983. Using capitalized quota values for Ontario the implied discount rate for industrial quota was found to be 10% above the prime interest rate and 85% above for fluid quota. This resulted in an implied discount rate of 11.6% for industrial quota and 19.4% for fluid with an average prime interest rate of 10.5% for 1986.

These supply prices have to be viewed with caution as they are only representative of a single method of estimation. Barichello (1984) estimated the supply price of milk in British Columbia to be $21.50 and in Ontario to be $22.50 using 1980 data. This is using a discount rate, with a default risk adjustment and growth factor included. The supply prices of Graham et al (1986) are approximately 40% greater in British Columbia and 45% greater in Ontario than those estimated by Barichello. Some of this increase can be attributed to the six years difference in data used but it is unlikely to be this great.

5.3 A No Policy Change Situation

The first scenario is meant to represent the Canadian dairy industry after the introduction of BST assuming no accompanying change in government policy. This implies quota levels, levies, subsidies and farm gate prices are all left unchanged. If production per farm or per cow is increased then the number of farms or cows in each of the provinces will be reduced since overall Canadian production remains constant under this scenario. This scenario is selected because it passes the full benefit of the adoption of BST on to the first group of economic agents, that is producers, but indirectly this group must also adjust their cow numbers or the number of farms. Farm gate prices remain static implying any fall in supply price is not captured in the regulatory cost of production formulas for industrial and fluid market milks.

This scenario is examined with both of the assumed sets of adoption rates in Table 3.3. The first situation assumes adoption rates to be a function of average provincial milk yields (scenario 1A). The second assumes adoption is a function of the distribution of provinces' farm herd size (scenario 1B).

The changes in herd size for this scenario as compared to the base case are presented in Table 5.2 These numbers are for mature dairy cows and do not include first lactation heifers. At the national level the reduction in herd size is 5.3% under Scenario 1A and 5.7% under scenario 1B. Ontario faces a herd reduction of 5.6% in both cases and Quebec's herd size falls just over 5% under

Table 5.2: Herd Size Changes with the Introduction of BST, by Province (thous hd)

Province	Base	Adoption Based on Ave. Yields	Herd Size
British Columbia	83.0	76.9 (-7.3)[a/]	77.7 (-6.4)
Alberta	130.0	123.5 (-5.0)	121.9 (-6.2)
Saskatchewan	59.0	56.8 (-3.7)	55.4 (-6.1)
Manitoba	71.0	67.9 (-4.4)	66.8 (-5.9)
Ontario	503.0	475.5 (-5.6)	474.6 (-5.6)
Quebec	615.0	583.4 (-5.1)	582.2 (-5.3)
Maritimes	86.4	81.2 (-6.0)	81.1 (-6.1)
Canada	1547.4	1465.2 (-5.3)	1459.7 (-5.7)

[a/] % changes from base in parenthesis

Source: CRAM model results

each adoption rate criteria. British Columbia has the greatest decrease in provincial herd numbers assuming either set of adoption rates. Under scenario 1A the herd size falls by 7.3% and 6.4% under scenario 1B. The prairies face the lowest reduction at 4.4% under scenario 1A. Under scenario 1B the herd reductions are greater than the national average at 6.1%. These differences are based upon the different assumptions regarding adoption rates by province.

The main effect of these changes on the dairy production sector are given in Table 5.3. Following from the definition of this scenario gross returns are unaffected. Any changes noted result from differences in variable costs and the returns from beef as a byproduct produced by the provincial dairy herds. Savings in variable costs of milk production, which at the national level amount to about 3%, can be attributed to several sources. Although the concentrate feed used to produce a hectolitre of milk with BST increases slightly the forages fed will fall substantially. The costs on an animal unit basis for items such as such as replacements, energy, veterinary and overhead will all fall as the milk yields are increased. On a provincial basis these costs fall by approximately 3% in each province. The province experiencing the greatest decrease in variable costs is Ontario, at just under 4 percent. The prairies have the lowest decrease at just over 2% in scenario 1A, they are about average at just over 3% under scenario 1B.

These falling herd sizes will mean less returns from beef

Table 5.3: **Changes in Dairy Production Subsector Earnings with Introduction of BST, by Province (mil $)**

Province	Fluid Market Gross Returns	Industrial Market Gross Returns	HQ and LQ Beef Gross Returns			Variable Costs			Dairy Producer Income		
			BASE	SCEN 1A	SCEN 1B	BASE	SCEN 1A	SCEN 1B	BASE	SCEN 1A	SCEN 1B
British Columbia	161.9	77.7	19.1	17.8	17.9	147.6	142.3	143.1	111.1	115.1	114.4[b/]
				(-7)[a/]	(-6)		(-3.6)	(-3.0)		(3.6)	(3.0)
Alberta	124.0	108.2	25.0	23.9	23.5	205.4	200.1	198.9	51.8	56.0	56.8
				(-4)	(-6)		(-2.6)	(-3.2)		(8.1)	(9.7)
Saskatchewan	51.3	41.9	10.2	9.8	9.6	81.2	79.6	78.5	22.2	24.5	24.3
				(-4)	(-6)		(-2.0)	(-3.3)		(10.3)	(9.5)
Manitoba	56.4	59.7	15.4	14.7	14.4	94.9	93.0	92.3	36.6	37.8	38.2
				(-5)	(-6)		(-2.0)	(-2.7)		(3.3)	(4.4)
Ontario	516.1	530.8	159.3	150.6	150.3	795.5	766.8	765.9	410.7	430.7	431.3
				(-6)	(-6)		(-3.6)	(-3.7)		(4.9)	(5.0)
Quebec	334.4	809.2	137.0	129.9	129.5	898.0	868.5	868.1	382.6	405.4	405.0
				(-5)	(-5)		(-3.3)	(-3.3)		(6.0)	(5.9)
Maritimes	114.1	68.5	21.1	20.0	19.9	150.0	145.2	145.0	53.7	57.4	57.5
				(-6)	(-6)		(-3.2)	(-3.3)		(6.9)	(7.1)
Canada	1358.2	1696.0	387.1	366.7	365.1	2372.6	2295.5	2291.8	1068.8	1125.4	1127.5
				(-5)	(-6)		(-3.2)	(-3.4)		(5.3)	(5.5)

a/ % changes in parenthesis from base case

b/ The low percentage change in B.C. dairy producer income with the adoption of BST, compared to the other provinces, is due to the unusually large gross margins in that province compared to variable production costs.

Source: CRAM model results

produced by the dairy herd. The total low quality (LQ) and high quality (HQ) beef returns fall by 5% under the first adoption criterion and 6% with Scenario 1B.. These numbers do not include vealor the transfers of animals to the beef sector (feedlot).

The reductions in variable costs lead to an increase in dairy production subsector income of over 5% in this scenario. Ontario experiences an increase of 5% and Quebec has a slightly higher increase of 6% in producer income. British Columbia has the lowest increase in income at 3.6% under scenario 1A and 3% under scenario 1B. The greatest increase is on the prairies where dairy producer income increases by over 7% with this scenario.

Along with the changes to the dairy production subsector movements of calves to the beef sector will be affected. The decline in dairy calves moving to the beef sector feedlots, as herd sizes fall, are given in Table 5.4.

In conclusion, in this scenario representing "no policy change" herd sizes fall by approximately 5 percent. This smaller herd size results in a decrease in variable costs of just over 3 percent. The fall in variable cost with no change in milk price or production levels results in approximately 5% increase in dairy producer incomes. At the national level the assumption on whether adoption rates are a function of average yields or herd sizes makes little difference in variable costs or the resulting dairy producer incomes. The only appreciable differences shown are in British Columbia where producers fare better when the assumed adoption rate is based on average yields. The prairies benefit more when

Table 5.4: Changes in Transfers of Dairy Calves to Beef Sector, Scenario 1

Province	Dairy Calf Transfers		
	Base	Scenario 1A	Scenario 1B
British Columbia	8,990	5,760 (-36)[a/]	6,210 (-31)
Alberta	88,290	83,650 (-5)	82,440 (-7)
Saskatchewan	29,950	28,360 (-5)	27,360 (-9)
Manitoba	40,750	38,560 (-5)	37,810 (-7)
Ontario	45,140	31,660 (-30)	31,210 (-31)
Quebec	92,060	72,900 (-26)	72,180 (-22)
Maritimes	34,540	31,960 (-7)	31,880 (-8)
Canada	339,720	292,850 (-14)	289,090 (-15)

[a/] % changes in parenthesis

Source: CRAM model results

adoption rates are a function of the herd size.

5.4 Change In Quota Values

Scenario 2 is used to measure what impact BST introduction has on quota values in the Canadian dairy industry. It is assumed that the representative farm in each province produces a blend of fluid and industrial milk and receives a blended price for this milk. The difference between this blend price and the supply price of milk will be the annual returns or 'rental value' of quota. These rental values are thus also based on a blend of fluid and industrial milks (Graham et al, 1989).

Producers who tend to purchase quota are most often those in the low cost category who wish to expand production levels. These producers will be in a position to bid for quota above what less efficient producers can pay. The market price of quota is determined by the present value of a stream of returns available to efficient producers in the dairy industry. These same producers will also be able to capture the greatest benefit from the adoption of BST. It is assumed 100% of these producers adopt. The difference between product price and marginal cost for these efficient producers is used to determine the changes in annual returns to quota with the introduction of BST.

The situation in this scenario is portrayed in Figure 5.2. The supply curve for the efficient producers in the industry shifts from S^0 to S^1 as illustrated in Chapter 2. This curve shifts down as a direct result of the lower average costs necessary to produce a given level of output (Q) with the adoption of BST. With a fall in marginal cost, constant product price and quota production levels this implies an increase in the annual returns to quota from ab to ac as shown in Figure 5.2.

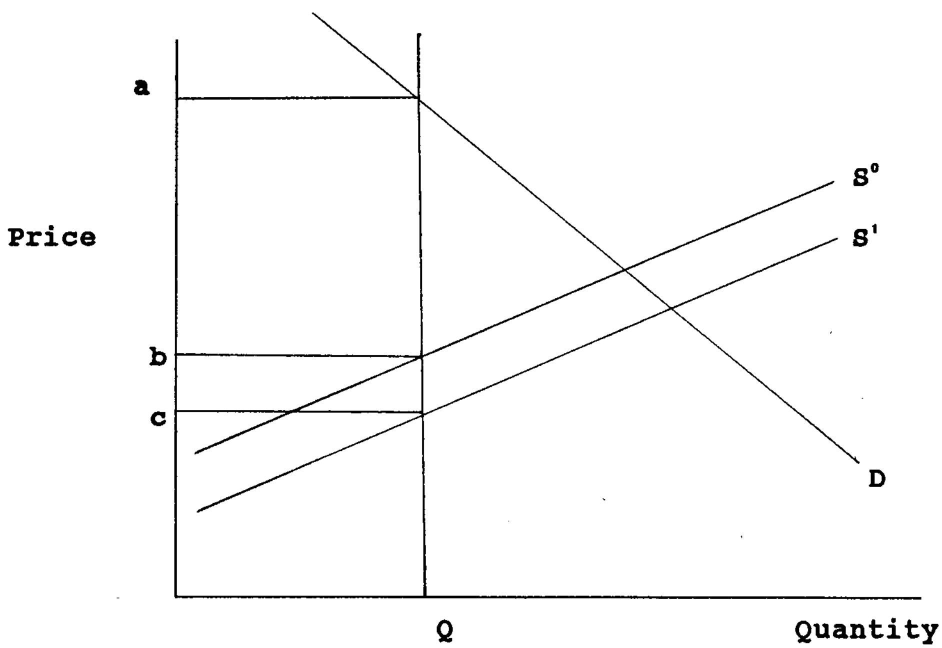

Figure 5.2: Supply Managed Industry With Falling Marginal Cost Curve

The blend prices of milk, supply prices and resultant annual quota returns, before and after BST is introduced, are given in Table 5.5. As in scenario 1 the assumption made is that all relevant policy instruments such as levies, subsidies, quota levels and farm gate prices remain unchanged. In Table 5.5 supply price and quota returns change, the blend price remains the same before

Table 5.5: Supply Prices Average Milk Prices and Annual Returns to Quota (Assuming Quota Adopters Affect Quota Values) Before and After BST Introduction, by Province ($/hl)

Province	Supply Price Before[a]	Supply Price After[b]	Average Milk Price[c]	Annual Returns to Quota Before	Annual Returns to Quota After
British Columbia	30.20	28.50 (-5.6)[d]	49.55	19.35	21.05 (8.8)
Alberta	34.80	32.65 (-6.2)	41.90	7.10	9.25 (30.3)
Saskatchewan	36.20	33.90 (-6.4)	44.81	8.61	10.91 (26.7)
Manitoba	32.60	30.70 (-5.8)	42.47	9.87	11.77 (19.3)
Ontario	32.60	30.70 (-5.8)	43.95	11.35	13.25 (16.7)
Quebec	31.60	30.00 (-5.1)	40.25	8.65	10.25 (18.5)
Maritimes	34.70	32.80 (-5.5)	44.33	9.63	11.53 (19.9)
Canada	32.40	30.60 (-5.6)	42.69	10.29	12.09 (17.5)

<u>Source</u>: [a] Model results calibrated to Mielke (1989) supply prices.
[b] Model results
[c] Mielke (1989)
[d] % changes shown in parenthesis

and after BST is utilized.

The supply price falls by 5.6% at the national level. This leads to a 17.8% increase in the annual returns to the blended fluid-industrial quota for Canada. Oxley et al (1989) showed a decrease in supply price for Ontario of 8% which resulted in a 23% increase in quota values. Tabi and Stonehouse calculated an increase in what farmers could pay for quota ranging from 8 to 29% depending on the farm technology level.

5.5 Quota Values Constant

This scenario is designed to represent a situation in which some of the benefits of BST adoption are passed on to the consumers. Quota values are held constant before and after BST use, by allowing expansion in production to keep the distance between supply price and farm-gate price the same. This expansion leaves producers at least as well off with BST introduction, and benefits some producers by allowing an expansion in production through more quota.

The main concept to be examined in scenario 3 is portrayed in Figure 5.3. The dairy industry prior to the introduction of BST produces at the level Q^0. This implies a farm gate price of PD^0 and a supply price of PS^0. The difference between these prices will be the annual rental value of quota. The introduction of BST causes a shift in the supply curve down to S^1 from S^0. In order to keep the rental value of quota and thus the capitalized price of quota the same after BST introduction the level of quota must be increased to Q^1. At this level the farm gate price is PD^1 with a supply price of PS^1. The difference between these prices is equivalent to the previous PD^0 less PS^0. As more milk is produced and marketed product prices to consumers are lower.

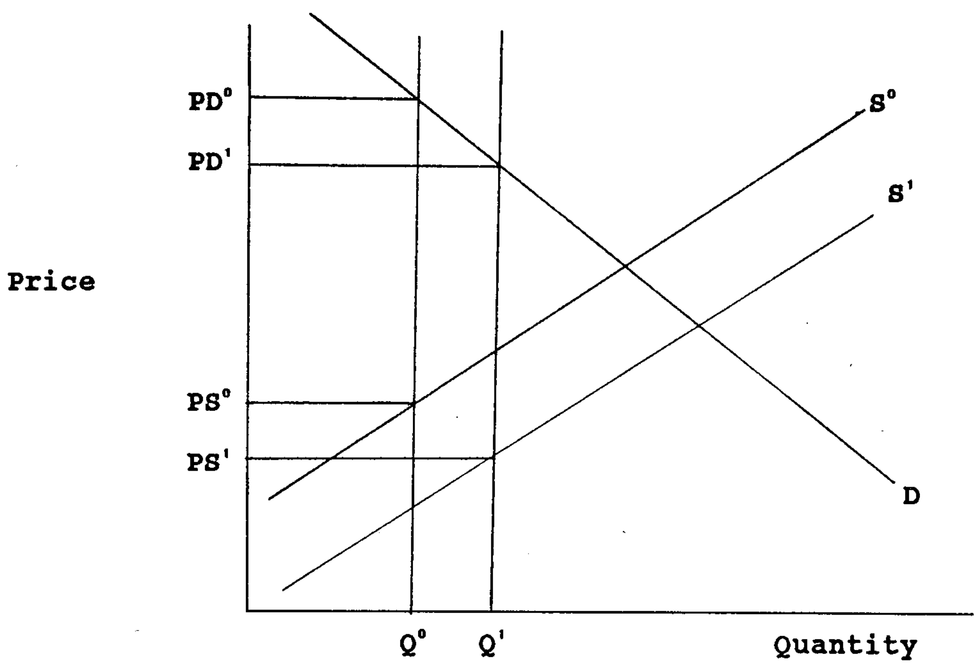

Figure 5.3: Expansion in Milk Output to Keep Quota Values Constant Before and After the Introduction of BST

The increases in production levels required to keep quota values the same as in the base case are given in Table 5.6. This analysis is on a provincial level treating the milk market as a single market producing both fluid and industrial milk. The ratio of fluid to industrial milk was kept constant in each province

Table 5.6: Milk Production for Scenario 3 Compared to Base, by Province (thous. hl)

	Fluid Production		Industrial Production		Total Production	
Province	Base	Scenario 3	Base	Scenario 3	Base	Scenario 3
B.C.	3119	3172	1770	1800	4889	4972 (1.7)[a]
Alberta	2579	2637	3324	3399	5902	6036 (2.3)
Sask.	974	997	1268	1298	2242	2295 (2.4)
Manitoba	1139	1163	1772	1808	2911	2971 (2.1)
Ontario	9920	10165	14475	14726	24396	24891 (2.0)
Quebec	6871	6996	21542	21935	28413	28931 (1.8)
Maritimes	2173	2216	2147	2189	4320	4405 (2.0)
Canada	26775	27346 (2.1)	46298	47155 (1.9)	73072	74501 (2.0)

[a] % changes in parentheses

Source: CRAM model results

as the total supply was allowed to increase. At the national level production was increased by over 1.8 mill. hl which is a 2% increase over the base case. Fluid market milk production increased by 2.1% and industrial market milk production increased by 1.9%.

The final processed dairy product mix which results from the new supplies of raw milk are listed in Table 5.7. For standard milk the western provinces increased production levels by slightly less than 3%, and in the east by 1.5% for an overall increase of 2% for Canada as a whole.

Lowfat milk production was up by slightly less than 3% in the western provinces and almost 3.5% in the east. At the national level this results in an increase of 3.2%. Cream production does not changes as the demand is essentially fixed for this product. In the industrial market cheese production increases substantially more than the other products. At the national level production increases 6.4%. Butter production also increases by slightly less than 2%. Skim milk powder is the only product which has a decrease in production under this scenario. With these increases in production for these final dairy products prices will fall.

Nearly all of the increased industrial milk production is used up for increased cheese production. The reason for this is that cheese has a much greater farm-gate wholesale margin than butter or skim milk powder. A great deal of the butterfat required for this cheese production is skim off from fluid lowfat milk production increases while the solid not fat comes from actual decreases in skim milk powder production. The increases in industrial milk production along with the transfers from the fluid market lead to a small surplus of butterfat. This is used by the modest increase in butter production.

Table 5.7: Increases in Processed Dairy Products for Scenario 3, by Province

Province	Standard Milk BASE	Standard Milk SCEN 2	Lowfat Milk BASE	Lowfat Milk SCEN 2	Cream BASE	Cream SCEN 2	Cheese BASE	Cheese SCEN 2	Butter BASE	Butter SCEN 2	Skim Milk BASE	Skim Milk SCEN 2
	(thous hl)						(tonnes)					
B.C.	842	866	1877	1928	209	209	11036	11407	4785	4881	5107	5107
Alberta	555	571	1776	1823	115	115	23135	25942	6883	7075	4190	4190
Sask.	230	236	710	729	37	37	8453	8852	2971	3042	1833	1833
Manitoba	287	295	710	729	49	49	10569	11427	4051	4131	1964	1964
Ontario	1874	1905	7589	7843	518	518	84661	89746	34715	37298	40014	38046
Quebec	2755	2801	3608	3729	322	322	77484	84294	39640	39195	53082	51057
Maritimes	882	896	1244	1286	54	54	14112	14602	5381	5515	4170	4167
Canada	7425	7570 (2.0)[a/]	17514	18067 (3.2)	1304	1304 (0)	231450	246270 (6.4)	98326	10026 (1.8)	110360	106364 (-3.6)

a/ % changes in parenthesis

Source: CRAM model results

The changes in movement of dairy products for scenario 3 over the base case are given in Table 5.8. At the national level cheese trade is fixed by import and export quotas, so these do not change. Canada is still just self sufficient in butter with no movement in or out of the country in this scenario. Skim milk powder exports fall by 6% at the national level.

At the provincial level movements of butter from Quebec to the western provinces fall by approximately 4%. The other significant interprovincial movement, cheese into British Columbia from Alberta falls by 39%.

Table 5.8: Changes in Dairy Shipping Activities with BST and Expansion of Quota Levels, thous. tonnes

	Cheese		Butter		Skim Milk Powder	
Province	Base	Scen 3	Base	Scen 3	Base	Scen 3
B.C.[a]						
Exports	0	0	0	0	0	0
Imports	17148	18636	6475	6378	0	0
ALBERTA						
Exports	1883	1156	6475	6378	0	0
Imports	0	0	7348	7060	0	0
SASKATCHEWAN						
Exports	0	0	7348	7060	0	0
Imports	0	161	7129	6770	0	0
MANITOBA						
Exports	0	161	7129	6770	0	0
Imports	0	0	6330	5892	0	0
ONTARIO						
Exports	0	0	6330	5892	23986	22018
Imports	0	0	11975	11664	0	0
QUEBEC						
Exports	12248	12497	12602	12157	41221	39196
Imports	2492	0	0	0	0	0
MARITIMES						
Exports	0	0	0	0	0	0
Imports	2821	3347	628	495	0	0
CANADA[b]						
Exports	12248	12238	0	0	65107	61214
Imports	20578	20578	0	0	0	0

[a] includes both interprovincial and international movements
[b] only international movements

source: CRAM model results

5.6 Reduction In Butterfat Subsidy

The final scenario to be addressed in this study is meant to pass the benefit of BST introduction to the taxpayer. This is accomplished by reducing the aggregate butterfat subsidy per province by an amount which will exactly offset the net cost savings through the use of BST. The subsidy is then calculated on a per hectolitre basis for industrial milk. The decrease in cost, per province, will be the value from scenario 1 with its assumed adoption rates for the 2 different criteria on adoption rates. Scenario 5A will have adoption rates as a function of average provincial yields and scenario 5B will have adoption rates as a function of the provincial farm herd size distributions.

The situation scenario 4 is attempting to model is described in Figure 5.4. Quota levels are set at Q with a farm gate price of 0a and a supply price of 0b. The annual returns to the asset quota are the distance ab. After BST the supply curve shifts from S^0 to S^1 and the supply price moves to 0c. The annual returns to quota will have increased by the vertical distance bc. This increase multiplied by the total production of milk will be the total reduction in subsidy for the province in question. The butterfat subsidy on industrial milk would be reduced by this amount divided by the production of industrial milk produced.

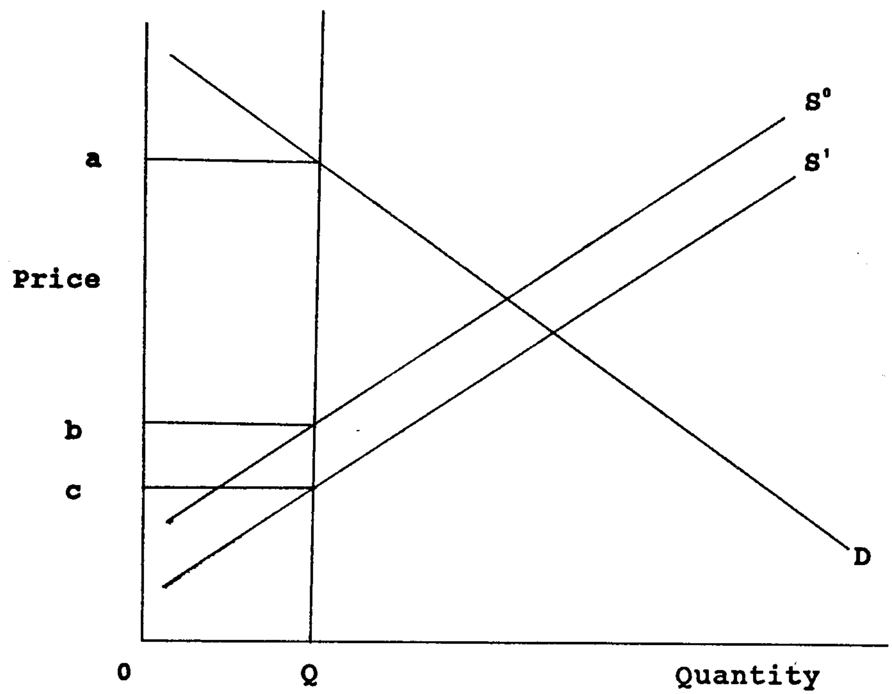

Figure 5.4: Reduction in Subsidy Payment to Offset Producer Benefit With the Introduction of BST

The results of these taxpayer savings are presented in Table 5.9. Total production is multiplied by the cost savings per hectolitre to come up with the total savings for the industry after adoption of BST. This value will be the total reduction in subsidy to offset this savings. The subsidy is only paid on industrial milk so the actual decrease in the subsidy per hectolitre must be calculated from the provinces' production of industrial milk.

Table 5.9: Savings by Taxpayers if Butterfat Subsidy Fell to Offset Cost Savings with BST

Province	Total Production (------ thous hl	Industrial[a/] Production ------)	Decrease in MC ($/hl)		Total Offset Savings (mill $)		Fall in Subsidy ($/hl)	
			Scenario		Scenario		Scenario	
			5A	5B	5A	5B	5A	5B
British Columbia	4889	1614	1.1	0.9	5.4	4.4	3.3	2.7
Alberta	5902	2765	0.9	1.1	5.3	6.5	1.9	2.3
Saskatchewan	2242	1078	0.7	1.2	1.6	2.7	1.5	2.5
Manitoba	2911	1772	0.7	0.9	2.0	2.6	1.1	1.5
Ontario	24396	14475	1.2	1.2	29.3	29.3	2.0	2.0
Quebec	28413	21542	1.0	1.0	28.4	28.4	1.3	1.3
Maritimes	4320	1930	1.1	1.2	4.8	5.2	2.5	2.7
Canada	73073	45167	1.1	1.1	80.4	80.4	1.8	1.8

[a/] net of overquota production

Source: CRAM model results

The butterfat subsidy has traditionally been set at the national level then applied to the provinces equally. The decrease in the subsidy would be 1.80 per hectolitre at the national level for either scenario. This would represent a savings to the taxpayers of over 80 million dollars, or approximately 30% of the current subsidy payments.

The smallest decrease in the butterfat subsidy necessary to offset the gains from using BST would be in Quebec at $1.30/hl. The reason for this is the high proportion of industrial milk produced. In Ontario the subsidy would fall by $2.00/hl.

The largest decrease in the subsidy to offset the producer benefits of BST use would be in British Columbia in scenario 5A at \$3.30/hl and both B.C. and the maritimes in scenario 5B at \$2.70/hl. The main reason for the large reduction in subsidy is the low proportion of industrial to fluid milk produced in these provinces.

The prairie provinces would require a \$1.60/hl reduction in the subsidy under scenario 5A and a \$2.10/hl reduction in scenario 5B to offset the fall in marginal costs as a result of BST adoption.

5.7 Summary

In this chapter the results of the introduction of BST to the Canadian dairy industry based on the model and assumptions stated in chapter 3 were presented. To facilitate this analysis a "base case" is compared to several scenarios representing different dairy policy options.

The first scenario representing "no policy change" (ie: quota levels, prices, levies and subsidies are constant) resulted in a dairy herd decrease of over 5% and an increase in producer incomes of approximately 5 percent.

The second scenario measured the change in quota values resulting from the introduction of BST. A blend of fluid and market share quota was assumed for reach province. This quota increase is estimated to be approximately 18%, nationally.

The third scenario passed some of the benefit of BST adoption on to consumers. This was accomplished by allowing the provincial production quotas to expand assuming that quota values remain at their 1986 "base case" level. This scenario resulted in a 2% increase in Canada's total supply of raw milk which was marketed with lower product prices.

The final scenario examined passed the benefit of BST on to the taxpayers. A reduction in the industrial milk subsidy was assumed which just offsets the decreases in variable costs due to the adoption of BST in Canada. This subsidy reduction was calculated to average $1.80/hl for the Canadian dairy sector. This reduction results in a savings to the taxpayers of approximately 80 million dollars.

Hence, if there are no changes in policy producers will capture the full benefits associated with the introduction of BST. This will be through increases in the rents associated with the quota and their asset values. Alternatively, some of these benefits could be passed on to either consumers or taxpayers. Consumers would capture some of the benefits, with no change to producers, if production were allowed to increase by 2% nationally. Taxpayers would capture the benefits if the dairy subsidy were decreased by $1.80/hl.

Chapter 6

Summary and Conclusions

In this chapter a summary of the study and some conclusions are presented. The first section will briefly outline the first five chapters including the problem to be addressed, the objectives, the model and the important results from the 4 scenarios. The next section presents conclusions drawn from these results and implications for policy. Limitations of the study and recommendations for further research are also discussed.

6.1 Summary and Conclusions

Bovine somatotropin (BST) is a naturally occurring hormone in dairy cattle which when subcutaneously injected into dairy cows allows for significant increases in the production of milk (Peel and Bauman, 1987; Burton et al, 1987; Soderholm et al, 1988; De Boer et al, 1988). When given and supplemented with increased feed levels a greater proportion of nutrients go toward the synthesis of milk (Chalupa and Galligan, 1988). The introduction of this product into an industry with production levels fixed through quota controls raises uncertainty with respect to its quantitative effects and the appropriate response by policy makers. The matter is further complicated by the possibility of a change in consumer preferences for milk when BST is widely used in dairy herds. This aspect is not addressed in this study.

The firm level impacts of BST have been analyzed in previous Canadian studies (Trelawny, 1986; Tabi and Stonehouse, 1988; Oxley et al, 1989) but no aggregate level studies are available. In order to examine different policy responses associated with BST introduction it is necessary first to answer questions relating to changes in aggregate herd sizes, marginal costs, dairy incomes and quota values. Hence, the major objective of this study is to assess the impacts of BST on the Canadian dairy industry at both the provincial and national levels. All dairy subsectors, including production, processing and demand subsectors will be examined in this analysis.

Biological experimental data on the effects of BST on dairy cows are from a study conducted at the University of British Columbia Oyster River Research Farm. This uses the largest herd treated with BST in Canada and covers a full lactation. This study provides information about the changes in milk yields and feed requirements resulting from BST application.

In order to examine these issues a programming model of the Canadian dairy industry was utilized. This model of the dairy sector is incorporated into the Canadian Regional Agricultural model (CRAM), (Webber et al, 1986). The dairy production component of CRAM is flexible in that it allows for changing government policy tools such as quota levels, subsidies and levies. The modification of coefficients for input utilization, yields, production costs and other important dairy sector activities is also facilitated.

Several scenarios representing policy alternatives are considered for the introduction of Bovine Somatotropin and are compared to a "base case" situation (1986) with no BST. The first scenario analyzed involves no government policy change in response to the introduction of BST. Quota levels, levies, subsidies and prices remained at their "base" levels. This situation was analyzed based on two different sets of adoption rates. The first based adoption rates on average provincial yields and the second distribution of provincial herd size.

In this first scenario the number of dairy cows in Canada decreased by 5% under both sets of adoption rates. British Columbia had the largest reduction in this scenario with a herd reduction of approximately 6.5 percent. Ontario and Quebec reduce their herd size by 5 percent. With falling herd numbers and cows producing the same total milk output levels an increase in dairy producer incomes of between 5.3 to 5.5% is predicted by the model.

The second scenario measured the change in quota values with the introduction of BST. Again, all policy instruments stay the same as in the base case. At the national level quota values increased by 17.5 percent.

In scenario 3 some of the benefits of BST adoption were passed on to consumers by allowing production to expand, and retail prices to fall with the difference between farm-gate price and supply price remaining the same after it's introduction. Therefore, quota values remain at their base case level. This resulted in a 2% increase in the supply of milk (both fluid and industrial) at the national level. In the fluid milk market the production of standard milk increased by 2% and production of the lowfat milk by 3% at the national level. In the industrial market the manufacturing of cheese increased by over 6%, butter production increased by approximately 2% and skim milk powder production fell by almost 4 percent.

In the final scenario the benefits of the introduction of BST are passed on to the taxpayers. This is accomplished by decreasing the industrial market dairy subsidy by an amount which just offsets the cost savings to each province as a result of BST adoption. This results in a decrease in the dairy subsidy of $80 million, or approximately 30% of the current amount paid out in subsidy.

In conclusion, under the assumptions made in this study, the impacts of BST adoption are quite moderate. At the firm level it is estimated that BST adoption would reduce a producers marginal costs by approximately $2.00 per hl on average in Canada. With the supply prices used in this study this represents a 5.5% reduction in marginal costs. Alternatively, if supply prices for an efficient producer are closer to $25.00 per hl this would be a larger reduction, at nearly 8 percent. Using the supply price in this study of $32.40 as an upper bound and $25.00 as a lower bound, quota values are estimated to increase between 10% and 17.5% with the introduction of BST.

The overall aggregate impacts of BST on the Canadian dairy industry are further moderated by the assumption that not all producers would utilize the hormone. The important results are a

5% decrease in dairy herd size and a 5% increase in dairy sector producer incomes which are both quite small.

The high degree of managerial skill required to profitably utilize BST, combined with early adoption of this technology by certain producers, would encourage high cost producers to leave the dairy industry. Early adopters of BST, facing reductions in cow numbers of approximately 10% to maintain current production levels, could be expected to purchase more quota to ensure full utilization of fixed resources. This is likely to accelerate the ongoing rationalization process of fewer but larger dairy farms with higher yields per cow.

Regulatory bodies responsible for dairy policy could direct any benefits resulting from BST in different directions. If production levels were to be expanded such that quota values didn't change, consumers would capture some of the benefit of BST. This would involve a moderate production increase and an accompanying decrease in dairy product prices. These price changes would be quite small but it can be argued that any lowering in the price of dairy products is important. Alternat-ively, if all of the increased rents associated with BST were passed on to taxpayers, through a reduction in the dairy subsidy, a burden on the Canadian taxpayers would be reduced.

At the international level, if the US adopts BST and Canada does not, this would increase the price differential between dairy products in these countries. In Canadian urban areas in close proximity to the US border, a considerable quantity of dairy products moves into Canada through consumer purchases. If the US dairy product prices fall relative to those in Canada, these consumer imports would be expected to increase, reducing the demand for Canadian produced dairy products.

With no accompanying change in Canadian dairy policy BST would only accelerate the ongoing trends in the Canadian dairy industry. Dairy industry rationalization, with decreasing producer numbers and increasing quota values would be temporarily accentuated.

6.2 Recommendations for Further Research

The preceding sections have presented the major findings of this study and the conclusions based on these findings. These results must be interpreted bearing in mind the simplifying assumptions used to model the dairy industry and the introduction of BST to that industry in this study. Some of the major concerns follow.

The major concern of this study relates to the assumptions on adoption rates. There is wide ranging speculation among industry experts on acceptance of this technology by producers in Canada. However, if full adoption of a new technology is assumed, and the resulting impacts noted, an upper bound on the estimated effects of the product is achieved. Under full adoption, as modelled in scenario 2 of this study, the impacts of BST are not large. Although the assumptions on adoption of BST are a source of uncertainty for this study, utilizing the results as noted above allows for a reduction in this uncertainty.

One possible alternative for determining these rates would be to endogenize the rate of adoption based on the profitability of BST. Another would be to use the Delphi Survey technique where several sets of questions concerning the adoption of BST are asked of a given group of producers in an interactive setting.

The analysis in this study ignores the issue of changing consumer preferences with the introduction of recombinant BST into dairy herds. Given the relatively moderate gains associated with the introduction of BST calculated in this thesis, any offsetting reduction in dairy product demand could conceivably erase these benefits. The complications of modelling and predicting this consumer response is work for another study. The possible impacts of this hormone on consumer preferences could be examined with the CRAM model by shifting the demand curve for BST treated milk by some predetermined amount. Another possibility would be to segment the dairy market into BST and non-BST treated dairy products with different production and demand functions. The impacts of the resulting lower dairy product and milk prices on dairy producer incomes and quota values could then be compared to the results of this study.

The supply prices for milk are critical to the analysis of the situation representing consumers capturing some of the benefit associated with BST. The information on quota values for each province necessary to calculate these supply price estimates is sparse and questionable. The collection of more accurate data on quotas and the methodology used to estimate supply prices needs further examination.

The shortage of long-term large scale experiments on BST leaves some unanswered questions with respect to the overall effects of this hormone. The effect of this hormone on the useful life of a cow still remains to be determined. If a cow does, on average, lose a lactation from her useful life this would entail a cost to dairy producers not covered in this study. Another related issue is the possibility of three milkings per day with the use of BST. It is anticipated that this will result in larger milk yield increases. As field experiments with BST yield more information on these problems this study should be updated.

In the BST experiment at Oyster River the control group of dairy cattle received the same dairy ration composition as the group receiving BST. Further gains in milk yields may be possible with dairy feed rations adjusted to meet the nutritional needs of animals receiving BST.

In this study a previous model of the Canadian dairy sector has been restructured and incorporated into the CRAM model. As a result the applicability and usefulness of the CRAM model has been increased. Important dairy issues can now be examined with CRAM. One important issue could include examining the impacts of liberalization of the Canadian border to dairy product trade. Another current issue is the debate over British Columbia's share of the industrial market share quota. The dairy portion of the CRAM model is well suited to examine these type of policy issues and others.

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