ADOPTION OF BOVINE SOMATOTROPIN IN THE UNITED STATES AND IMPLICATIONS FOR INTERNATIONAL TRADE OF DAIRY PRODUCTS

A thesis presented in partial fulfilment
of the requirements for the degree of
Masters of Agricultural Economics

Massey University

Palmerston North, New Zealand

Joseph William Guthrie
1992

Abstract

Advancements in biotechnology have led to some of the most important changes in agriculture in this century. The development of synthetic bovine Somatotropin, a hormone which increases milk production from dairy cows, may have a significant impact on the dairy industry in the near future. While bovine Somatotropin, or bST, has been widely studied, its potential impacts, both on milk production and on the economics of the dairy industry, remain controversial.

At this time, bST has not been approved for use in any of the developed countries. It appears that, for a variety of reasons, the United States would be the most likely to approve bST in the near future. If bST is approved in the US, and widely adopted by American farmers, it could increase milk production in the US significantly, although the exact magnitude of its effects are difficult to determine at this time.

Another important factor in determining US milk production is the US government's dairy policy. The policy for 1991-1995 is contained in the recently passed 1990 Farm Bill. The dairy provisions in the 1990 Farm Bill will maintain the current support price for milk at its current level, regardless of how large dairy surpluses become.

Together, the increase in milk production from bST along with a guaranteed minimum support price could lead to significant surpluses of dairy products in the US by 1995. Since the US has traditionally sold its dairy surpluses on the international market at subsidised prices, or simply given them away as food aid, a large increase in US surpluses could have a great impact on the international dairy market. Furthermore, because the 1990

Farm Bill was only passed recently, no studies have yet been published which address the impact of bST under the current policy environment or what effect this would have on the world dairy market.

The objective of this study is to empirically estimate the impact of bST on US production, and determine the implications for international trade of dairy products. A five equation quarterly econometric model of the US dairy industry is used to forecast US production through 1995. Then the effects of bST use are incorporated into the model.

The results show that if bST is adopted in the US as assumed, by 1995 surpluses of dairy products could rise to as much as 12 billion pounds. This surplus would be nearly as large as the record surpluses of the early 1980's, which caused unprecedented disturbances to the international dairy market.

Thus, use of bST in the US could significantly increase the excess supply of dairy products in the world, and thereby lower prices, especially of butter and skim milk powder. New Zealand would be particularly vulnerable to any price reductions on the world dairy market. The European Community, which is the largest exporter of dairy products, may have to increase its own export subsidies to compete against the US. This, in itself could lead to even further turmoil in the world market.

Acknowledgements

Several people have helped me considerably in completing this work. In particular, I would like to thank Dr. Doren Chadee, my advisor, for his assistance in the development and analysis of the model, and his unfailing support. I would also like to acknowledge the rest of the faculty and staff of the Department of Agricultural Economics and Business at Massey University, all of whom have assisted me in some way during the development of this thesis.

I owe a special debt of gratitude to the New Zealand-United States Educational Foundation. Without their financial support, I would not have been able to study in New Zealand at all, much less write this thesis. In particular I would like to acknowledge Mr. Laurie Cox, the Executive Director of the foundation, for his support throughout the time I spent in New Zealand.

Finally, I would like to thank my family and friends "back home." Although they were far away, they remained close. Their support and encouragment were a great help, and greatly appreciated.

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Chapter 1

Introduction

Some of the most important and far-reaching advances in agriculture in this century have been brought about as a result of the widespread adoption by farmers of the latest developments in biotechnology. One of the most widely discussed topics in biotechnology in recent years is the development of synthetic bovine Somatotropin, or bST.

BST is a hormone which cattle produce naturally, but scientists have been able to produce synthetic bST, which has all the same effects. Dairy cows which are treated with daily injections of bST produce more milk with no apparent harm either to the cow's health or to the quality of the milk. Estimates of the amount of increase in milk production due to bST use vary, but bST may increase milk production by as much as 20%.

At present, bST is still being tested, and has not been approved for use in any of the developed nations. It has never been shown to be a risk either to people or cattle, but its use remains controversial. Aside from health concerns, bST has sparked controversy because many believe it could fundamentally restructure the dairy industry wherever it is used. Of the major dairy producing nations, the US would appear to be the most likely country to approve bST in the near future, perhaps sometime in 1992. Even in the US, however, it remains quite controversial.

Much is still unknown about bST. One debatable issue is how many farmers would adopt bST if it were approved. This would depend most likely on other currently unknown factors such as how much bST would cost, how much it increased milk production per cow, the price the producer received for milk, and other factors. Another controversial issue is how well consumers would respond to milk that had been produced from bST-treated cows.

1.1: Statement of the Problem

Although several studies have estimated the economic impact that bST would have if it were adopted in the US, these studies are found to be lacking in what this author feels are two vital concerns. One is the change in the policy environment since these studies were written. The other is their lack of analysis of the effects that bST could have in making the US a larger exporter of dairy products, and the effects that increased exports by the US would have on international dairy trade.

Previous studies were based to a large extent on the assumption that the dairy policies in the US from the late 1980's would continue into the 1990's. However, since these studies were completed, the 1990 Farm Bill, which will guide US dairy policy from 1991 through 1995, was passed and went into effect. It altered the dairy price support system that had been in place since the passage of the 1985 Farm Bill. Thus, these previous studies haave become somewhat outdated.

Furthermore, most studies which analyse bST's effects on the US dairy industry do not carry that analysis over to an examination of the impacts it would have on the international dairy market. One study which did concluded that bST may play a part in making the US a larger exporter of dairy products. It was based, however, on the same assumptions that were discussed above, that the 1985 Farm Bill policies would be continued in the 1990 Farm Bill. Therefore, that study's conclusions may not accurately show the most probable effects of the use of bST in the US on the international dairy market.

There is, therefore, a lack of information on the effects that the adoption of bST will have on the US dairy industry, and the implications for international trade of dairy products. Since the effects of bST use could be very significant, an indepth analysis is needed to estimate the effects that bST could have if it is adopted in the US under the current policy environment. This analysis could then be used to determine the implications for the international dairy market.

1.2: Objective

This study will estimate the effects that adoption of bST in the US will have on the US dairy industry and the implications for international dairy trade. The purpose is to gain a better understanding of the effects of bST, and of the US dairy industry under the current policy environment, in order to forecast with a greater deal of confidence what the effects of bST use will be.

1.3: Methods

The general procedures followed in the study include the specification and estimation of an econometric model of the US dairy industry. The econometric model is then simulated to generate forecasts of the endogenous variables for the 1991-1995 period. Based on these forecasts, several scenarios of the use of bST under various assumptions are developed in order to analyse the empirical impacts of bST on the US dairy industry, and the resulting impacts of the excess supplies from the US that could be traded on the world market.

1.4 Outline of the Study

The next chapter in this study discusses the US dairy industry and the current dairy policies in the US. It then gives an overview of the policy environment around the world, with particular emphasis on the leading dairy exporters, the EC and New Zealand. That chapter then explains the current situation in world dairy trade, and how the US could emerge as a larger exporter. Chapter 3 discusses the impacts of bST, and reviews the literature of the economic impact of the adoption of bST in the US.

Chapter 4 gives a conceptual model of the effects of bST in the US. Chapter 5 explains the model that was used to estimate the supply, demand, and prices for dairy products in the US and shows the empirical results that were obtained. It also shows how the model was validated, and the results of using the model to forecast over the 1991-1995 period. Chapter 6 shows how the adoption of bST was incorporated into the model, and discusses the implications for international dairy trade. Chapter 7 gives a summary of the study, the conclusions that can be drawn from it, and suggestions for further reserch.

Chapter 2

An Overview of the US Dairy Industry, the World Dairy Policy Environment, and World Dairy Trade

2.1: Introduction

It is important before proceeding to the model to gain a good understanding of the US dairy industry. This would, of course, include a review of the US government's dairy policies and programs. Because this thesis is also concerned with international dairy trade, it is also important to review government intervention in the dairy industry of other nations, in particular the major dairy exporters, the EC and New Zealand. The current situation in the world dairy market must also be considered.

The first part of this chapter will briefly describe the US dairy industry. In particular, it focuses on trends in production and consumption, and on the government programs which support the US dairy industry. The chapter then discusses the dairy policies in other nations, with particular emphasis on the EC and New Zealand. The third part of the chapter gives an overview of the current situation in world dairy trade. The final section of the chapter discusses the possibility of the US becoming a larger exporter of dairy products under the current policy environment.

2.2: The U.S. Dairy Industry and Dairy Policy

2.2a: Introduction

The US is one of the world's largest dairy producing countries, and dairying accounts for a significant part of the nation's total agricultural production. In 1990, milk production totalled over 65 million metric tonnes, or over 145 billion pounds (IDA,1990). Total farm revenues for milk average over US$ 15 billion per year. Yet, the US has traditionally been a relatively minor participant on the international dairy market. In most years, production is almost entirely consumed on the domestic market, although surplus government stocks are occasionally disposed of on the international market. Strict quotas limit imports to prevent cheaper foreign goods from undercutting the domestic price, which is supported by the government. The following section takes a closer look at the US dairy industry, and the government policies and programs which affect it.

2.2b: Dairy Production in the U.S.

American dairy production has traditionally been dominated by "family" farms. These farms are relatively small and numerous, with moderate entry and exit constraints. Therefore they can be categorised rather accurately as perfectly competitive.

As Table 2-1 shows the structure of the US dairy industry has been shaped by trends toward increased milk production per cow and decreasing numbers of cows and dairy farms during the past 30 years (Fallert, Blayney, and Miller, 1990). Use of bST could contribute to continuing these trends in the future.

Table 2-1: Structural Changes in the US Dairy Industry, 1955-1989

	1955	1975	1989	% Change 1955-89
Cows ('000 head)	21,044	11,139	10,127	-52%
Farms with Milk Cows ('000's)	2,763	444	160	-94%
Ave. No. of Cows per Farm	8	25	49	513%
Milk per Cow (lbs/year)	5,842	10,360	14,244	144%
Total Milk Produced (Million lb.)	122,945	115,398	145,252	18%

Source: USDA

Despite the changing structure of the industry, total production has increased only marginally in the past 30 years, due to relatively steady per capita consumption. Another important trend during the 1980's has been the willingness of the American dairy farmer to produce more milk for lower real prices, due at least in part to rising farm efficiency. Despite improved efficiency, lower prices have led to declining farm earnings throughout most of the 1980's.

2.2c: U.S. Dairy Policy

While dairy farms are almost perfectly competitive price takers, dairy processing plants are oligopolistic firms with considerable regional market control. Therefore, there has been a perceived need to protect farmers from the full force of market shifts. In response, the federal government instituted two major dairy programs during the Great Depression, which are still in effect, and largely unchanged, today. These are the federal market order program and the price support program.

2.2d: The Federal Milk Market Order Program

The Federal Market Order Program sets minimum prices that milk processors must pay farmers (or their cooperatives) for fluid grade milk in a given market order area. Not all of the nation is included in the 48 federal market order areas, but these areas account for over 80% of the fluid milk produced. The program was designed to prevent processors from using monopsony power in purchasing milk and to differentiate prices between fluid grade milk and milk for manufacturing purposes (Knutson, Penn, and Boehm, 1983).

In the program, fluid milk is priced at a higher level than manufacturing grade milk, due to the more inelastic demand for the fluid milk. Therefore, the price discrimination results in higher returns to producers. Since orders only prescribe minimum prices, the price paid to farmers may actually be higher (Knutson, Penn, and Boehm, 1983).

The price used to determine the minimum prices in the federal market order program is the Minnesota-Wisconsin price (M-W price). The M-W price is the price processors pay farmers for manufacturing grade milk in the Upper Midwest, the nation's largest milk surplus area. The price for manufacturing milk in each federal order area around the country is set at the M-W price, and the price for fluid grade milk is set at a premium above the M-W price. Then a transportation differential is added to reflect the cost of shipping milk from Wisconsin to a given federal order area. Each farmer in the federal order area then receives the same price for milk, regardless of which processor the farmer sells to.

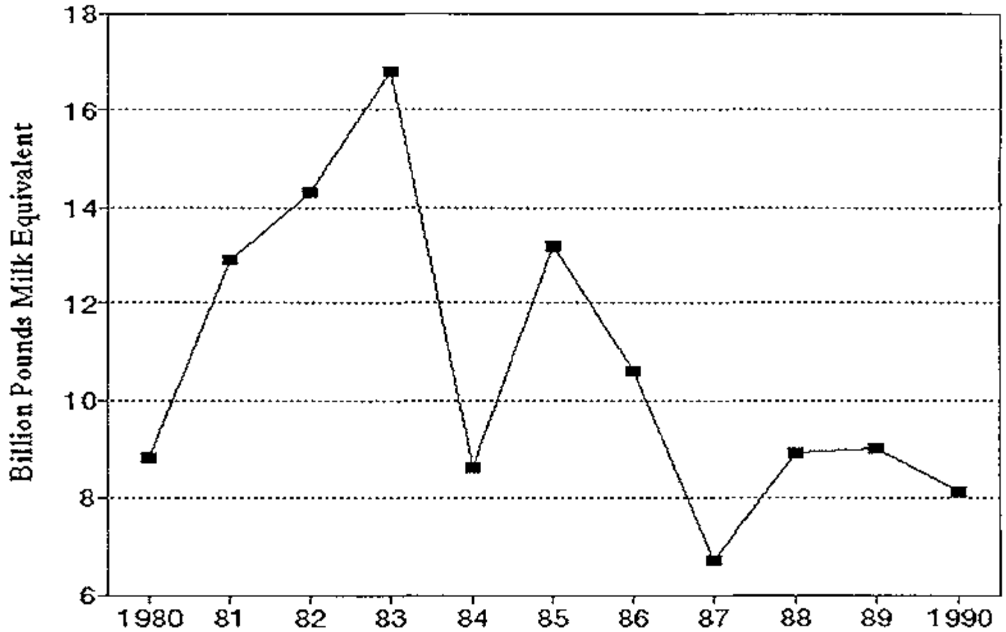
The appropriateness of the M-W price has come under close scrutiny recently. It is generally acknowledged that the M-W price is a fair reflection of the price of manufacturing milk, but some farm groups, especially those in the Upper Midwest, argue that it does not set appropriate prices for fluid milk. Because of this concern, an alternative pricing mechanism may be forthcoming, although no clear alternative has yet been presented.

2.2e: The Price Support Program

The Price Support Program is designed to maintain reasonable and stable prices for milk and dairy products, and is operated by government purchases of dairy products. In this program, federal law periodically establishes a minimum support price for milk. Whenever the market price falls below the support price for a specified length of time, the Commodity Credit Corporation (CCC) of the U.S. Department of Agriculture (USDA) purchases butter, cheese, and nonfat dry milk (skim milk powder) on the open market and then removes them from the market until the price returns to the support level. CCC purchases are stored until they can be resold on the open market at higher prices, used in federal nutrition programs, donated to foreign aid programs through PL 480, or sold on the international market. To prevent cheaper imports from undercutting the supported price, a quota is imposed on the import of dairy products, which usually amounts to about 2% of total supply. Unlike federal support programs for other agricultural commodities, such as wheat, the dairy support program does not require farmers to control production to qualify for the benefits of the supported price.

The support price program was originally designed to moderate seasonal supply and demand differences because supply is traditionally greatest in the spring while demand peaks in autumn. During the 1980's, however, the program has been more annual in nature. Throughout the early 1980's excess supplies led to dairy surpluses and low prices, forcing the CCC to purchase huge quantities of dairy products throughout the year, as shown in Figure 2-1.

Figure 2-1: CCC Net Removals, 1980-90



Source: USDA Dairy Sit. & Outlook Report

2.2f: Dairy Policy Changes in the 1985 Farm Bill

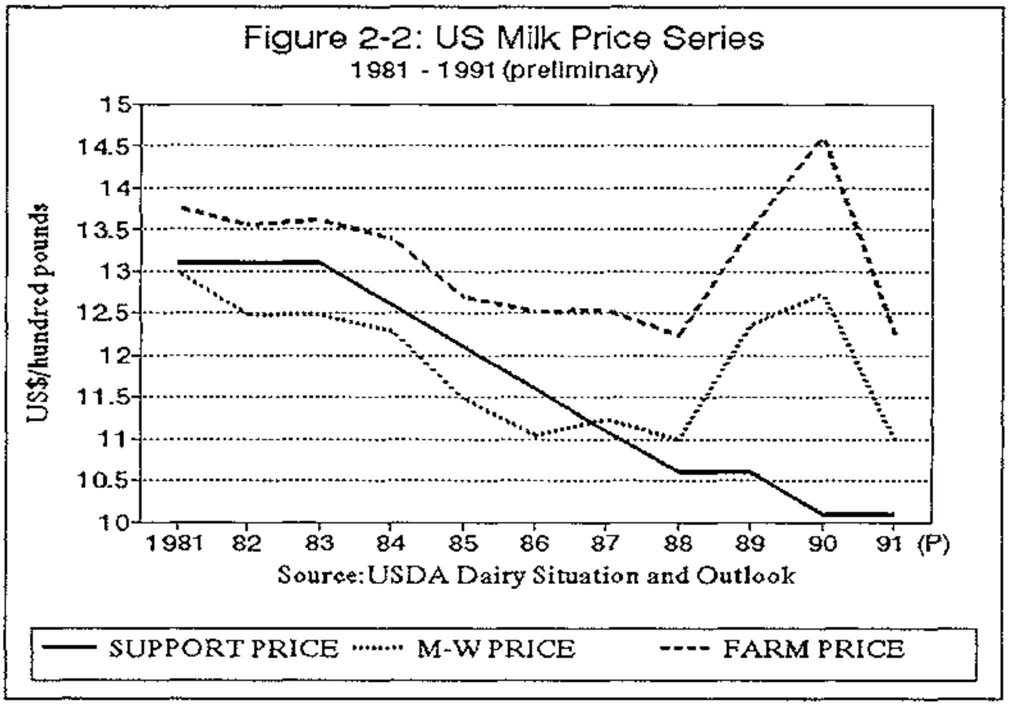
The huge costs incurred through purchases and storage of dairy products, along with growing concern over the federal budget deficit, led Congress to extraordinary measures in the

1985 Farm Bill. The 1985 Farm Bill authorized a whole-herd buyout program, called the Dairy Termination Program (DTP) and a declining support price.

The DTP allowed farmers to dispose of their cattle and remain out of dairying for five years, in return for government payments. The program removed one million cattle and 12 billion pounds of annual production capacity from the market. Part of the cost of the program was paid by producers through a $.40/cwt assessment on milk sales.

The 1985 Farm Bill also called for a fundamental shift in the way support prices were to be calculated. Instead of continuing to link supports to parity prices, the Farm Bill authorized the Secretary of Agriculture to reduce the support price by $.50/cwt whenever annual CCC purchases were projected to be above five billion pounds. USDA economists believed up to five billion pounds of dairy products could be disposed through aid and nutrition programs without creating market disturbances and without forcing the US to dump dairy products on the international market. This policy led to the support price's fall, in nominal terms, from $12.60/cwt. to $10.10/cwt. between 1985 and 1990 (Dairy Situation and Outlook).

These provisions of the 1985 Farm Bill largely succeeded in their objectives of reducing government surpluses while maintaining farm income. By 1990, surplus stocks of butter, cheese, and skim milk powder were at historically low levels. Also, while the support price has been falling, prices farmers received for milk generally rose from 1987, when the effects of the DTP were first felt, through 1990. In fact, the M-W price and the average price farmers received for milk reached all-time highs (in nominal terms) in the fourth quarter of 1989, due largely to a low supply of milk caused by a widespread draught. Prices have since declined rapidly, however, as displayed in Figure 2-2.



2.2g: The 1990 Farm Bill and GATT Negotiations

The policies and programs for the US dairy industry for 1991-95 were adopted as part of the 1990 Farm Bill. Another important factor which may shape dairy policy through the decade is the ongoing multilateral trade negotiations held under the auspices of the General Agreement on Tariffs and Trade (GATT).

The GATT negotiations, popularly known as the Uruguay Round, are attempting to liberalise world trade in agricultural products. However, failure in these negotiations could lead to more restrictive trade if a trade war subsequently develops between the two largest agricultural traders, the US and the EC. Also, for any agreement reached in the Uruguay Round to be approved by the US Congress, it will most likely have to be compatible with the 1990 Farm Bill.

In anticipation of the possibility of a trade war, the 1990 Farm Bill, which became effective at the beginning of 1991, is largely defensive in nature. The Farm Bill's dairy provisions call for maintenance of the current $10.10/cwt. support price, regardless of dairy product purchases. This contrasts with the 1985 Farm Bill which, as explained in the preceding section, allowed the support price to fall if anticipated dairy product purchases exceeded a certain level.

Unlike the 1985 Farm Bill, however, the new legislation limits outlays for CCC purchases to 7 billion pounds per year. Funds for additional purchases of dairy products necessary to maintain the support price would come from the producers themselves through an assessment on their milk sales. In particular, only the farmers who increased production from the previous period would be forced to pay the assessment.

This legislation allows the maintenance of a steady support price, something that was lacking in the 1985 Farm Bill, but also protects the CCC from being forced to purchase huge quantities of dairy products to maintain that support price. It also provides an incentive for farmers not to overproduce, since only the ones who increase production would pay the assessment to maintain the support price.

It is not clear how this new legislation would affect the adoption of bST. Dairy producers would obviously have less incentive to increase their total milk production. However, bST would allow farmers to maintain their current production with fewer cows, and thus lower total costs. Depending on price levels, it is possible that farmers could even maximize profits by increasing production above their current levels if the benefits from using bST outweighed the costs of paying the assessment.

2.3: The World Policy Environment

2.3a: Introduction

As the previous section showed, government intervention is a major influence in the dairy industry of the US. The same is true for most of the other developed nations of the world. This section examines the government policies of other nations, particularly the major participants in world dairy trade, the EC and New Zealand.

2.3b: Overview of the World Dairy Policy Environment

The dairy products industry is among the most heavily subsidised, and most rigidly protected, industries in the world. Most nations defend their subsidies to dairy producers as being necessary to insure the nation an adequate supply of milk and dairy products at stable prices while providing an acceptable return to farmers. Likewise, the stiff tariffs or quotas most nations impose on imports of dairy products are put in place to protect domestic dairy farmers from cheaper, and often subsidised, imports.

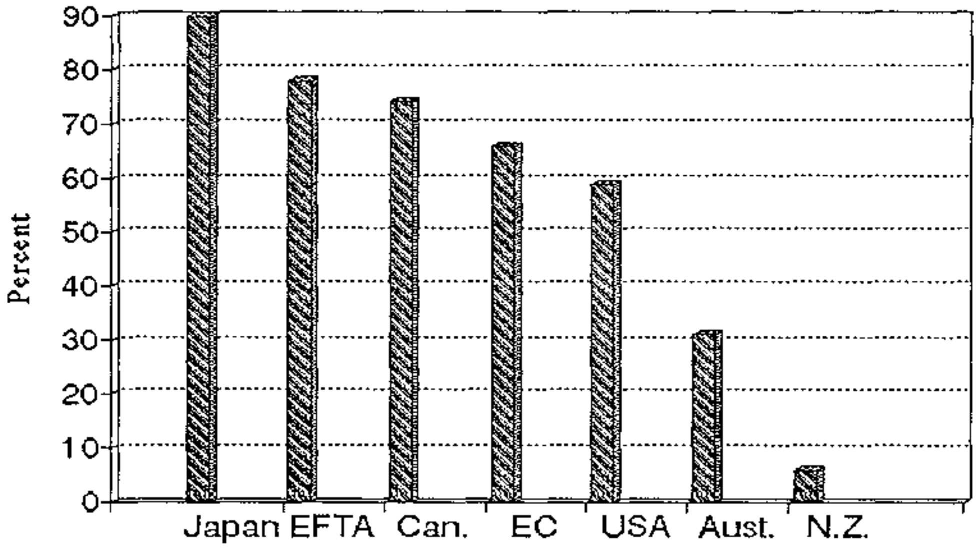
2.3c: Measuring Government Intervention in the Dairy Industry

Not only is there is a tremendous amount of government intervention in the dairy industry around the world, but there is also a great deal of diversity between programs in various countries. In order to negotiate reductions in subsidies and protection in agriculture, as the recent GATT round of talks has attempted to do, it is first necessary to be able to measure the total effects of all these diverse programs.

The most commonly used measure is the Producer Subsidy Equivalent (PSE). The PSE is a measure of the amount of income that a producer would have to be compensated for the removal all government supports under current programs and current prices. A similar measure, the Consumer Subsidy Equivalent (CSE) measures the amount of income that a consumer would have to be compensated for the removal of government support. PSE's and CSE's are aggregate measures of support representing the degree to which a particular agricultural commodity sector is influenced (Roningen and Dixit, 1989). Because the usual case is a policy where producers are supported at the expense of the consumer or taxpayer, the PSE's is nearly always positive, while the CSE is nearly always negative.

Figure 2-3 shows PSE's for milk in the OECD countries, expressed as a percentage of the price producer received for milk.

Figure 2-3: Milk PSE's As a Percent of Producer Price in OECD Countries, 1988



Source: OECD

As the graph shows, Japan leads the world in the support it gives its dairy farmers. The Japanese are followed closely by the nations of EFTA, the European Free Trade Association, which are the non-EC countries of Western Europe. Canada, the EC and the US also have high levels of government intervention. In contrast, Australia and particularly New Zealand have very low levels of government support and protection.

As is the case with most products, those countries which are higher-cost producers tend to give higher subsidies and impose stricter controls on imports, than the lower-cost producers. This follows logically from the supposition that a low-cost producer would not need protection from imports, because the imports would be more expensive than the domestic product (assuming no export subsidies were used by other nations). For example, Japan and the EFTA countries have particularly high levels of government intervention, and are also among the highest-cost producers of milk in the world. New Zealand, in contrast, is the world's lowest-cost milk producer, and has relatively little intervention by the government.

Since the EC and New Zealand are the two largest dairy traders in the world today, and since their actions largely determine the shape of the world dairy market, their dairy policies and programs will be described here. Their vastly different policies also makes for an interesting study in the contrast between a heavily subsidised dairy industry and a non-subsidised one.

2.3d: Dairy Policy in the European Community

In the EC, dairy policy is part of the Common Agricultural Policy, which has governed agricultural policy in the Community since 1956. There were originally two basic policy mechanisms for dairy, as for most agricultural commodities. The first is a market intervention system used to achieve politically determined farmgate prices. At the external frontier, this domestic marketing pricing structure was protected from disruption from the outside world by variable import levies and export subsidies.

Milk prices are supported by intervention buying of butter and skim milk powder at guaranteed prices. These products are then removed from the domestic market, keeping the price market price at least as high as the guaranteed intervention price. The intervention price is formulated in such a way as to give dairy farmers a "target price," for raw milk and insure them an adequate return, but this does not always happen in actual practice (Clough and Isermeyer, 1985).

The dairy products purchased in the intervention programme must then be stored or resold on the world market, usually at prices below the intervention price. This often requires the EC to lower the price of these goods through use of export subsidies, and then sell them at below the world market price. This policy also creates a high opportunity cost for other dairy products, especially cheese, which must also be sold on the world market, again at subsidised prices. Storing and selling these dairy products has been tremendously expensive to the EC, especially during the early 1980's. Sales of subsidised goods have also tended to be irregular and disruptive to world dairy prices (Clough and Isermeyer, 1985).

To help combat these problems with surpluses, the EC has adopted measures to reduce milk production including a "co-responsibility levy" and quotas on farm milk production. The co-responsibility levy is essentially a tax which is set at 1.5% of the target price and is collected from suppliers to help pay the cost of disposing of surpluses. However, the levy was not effective enough in reducing supplies, so a quota was added in 1984. Any milk sold by the farmer (or, in the case of some countries, the dairy factory) in excess of their assigned quota incurred a hefty levy, making production above quota levels unprofitable. (Clough and Isermeyer, 1985)

The EC protects domestic producers by imposing a variable import levy on dairy imports. The levy raises the price of all imports to a specified "threshold" price. This means that all imports, regardless of their price upon entering the EC port, must be marketed at the threshold price. Since the threshold price is set above the intervention price, domestic price programs are protected from cheaper imports. Although suppliers can theoretically ship unlimited amounts of dairy products to the EC, the levy makes it unprofitable for them to do so since import prices are raised above the price of similar domestic goods. However, special arrangements have made specified quantities from certain suppliers, most notably New Zealand, exempt from the variable levy. (Clough and Isermeyer, 1985)

2.3e: Dairy Policy in New Zealand

New Zealand farmers were once heavily subsidised by the government. However, these government supports and protections have been phased out since 1984, and New Zealand farmers now receive virtually no government support. There are no direct payments to farmers, no production incentive programs or production quotas, and no border protections. Only small residual indirect supports, such as disaster relief programs and government funded research, remain. One aspect of the pre-1984 policy that has been maintained is the New Zealand Dairy Board, a farmer-run corporation, which acts as the sole exporter of New Zealand's dairy products (NZ Dairy Board, 1990). A special provision allows the Dairy Board a monopoly over dairy exports.

2.4: The World Dairy Trade Situation

2.4a: Introduction

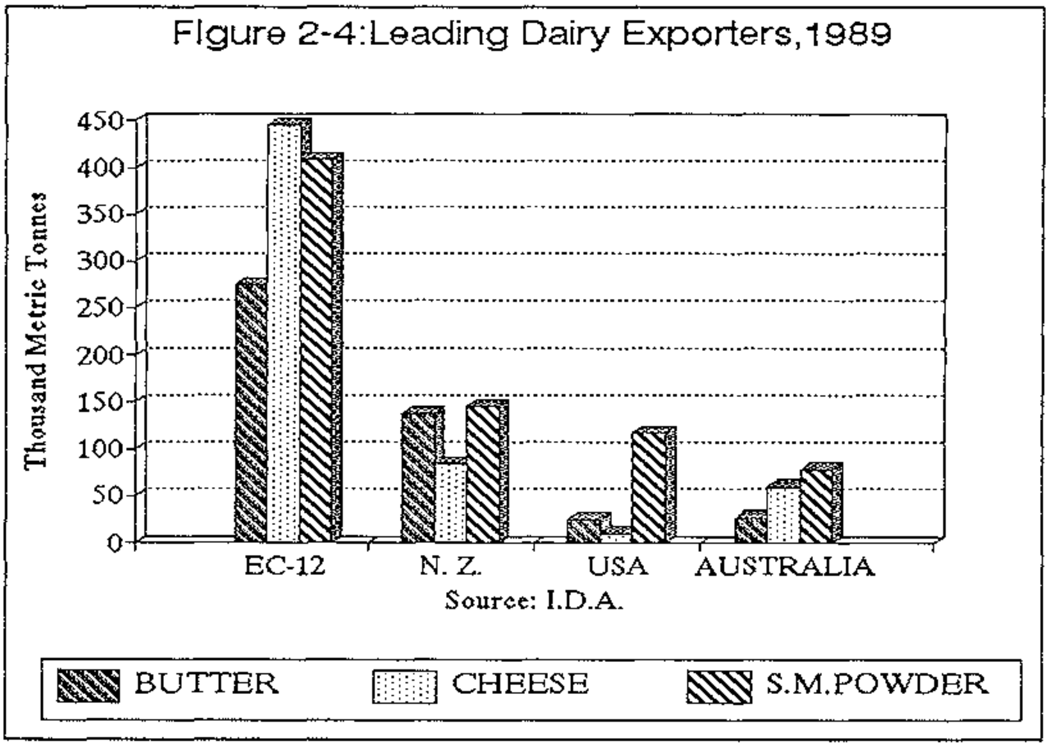
The previous sections showed the large effect that government intervention has on most of the developed world's dairy producers, New Zealand excepted. The price supports, trade barriers, export subsidies, and other programs employed by the US, the EC, and others impact upon the world dairy market both directly and indirectly. This section discusses the current situation in the international dairy market. It also reviews recent trends in trade levels and prices.

2.4b: An Overview of World Dairy Trade

World production of milk totalled over 530 million metric tonnes in 1989. Yet, only about 5% of this total was traded between nations, and approximately 20% of the total traded was actually donated as food aid. Thus, production of milk and dairy products is a large part of the agricultural sector, but it comprises only a small part of world agricultural trade (IDA, 1990).

One factor that limits dairy trade is simply the perishability of milk. Because even pasteurised milk remains fresh only for a couple of weeks, international trade of milk is virtually impossible. Milk is also a very bulky commodity, consisting mainly of water, and is quite expensive to transport. Thus, virtually all trade consists of dairy products, mainly butter, cheese, and milk powders.

Figure 2-4 shows some of the main exporters of dairy products.

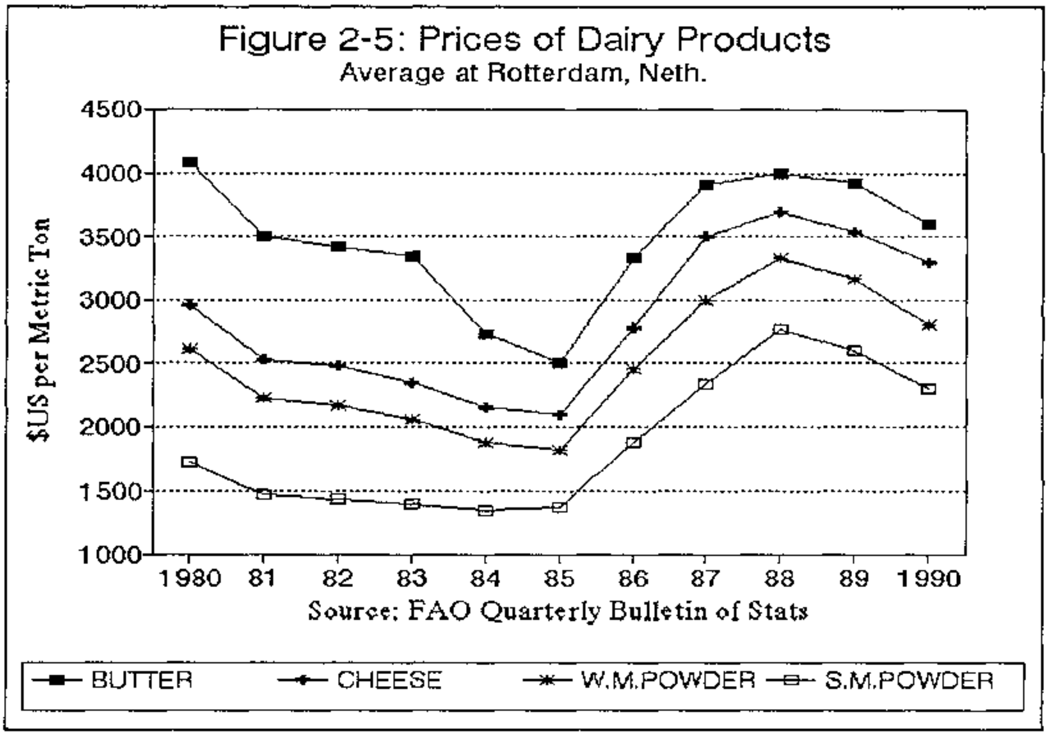


As the graph illustrates, the EC is by far the leading exporter of all three dairy products. New Zealand maintains the next largest share of dairy exports. The United States is a large exporter of skim milk powder, and an occasional exporter of butter, but is a net importer of cheese (the graph shows total exports, not net exports). Australia also maintains a fairly large role in skim milk powder exports. Major importers of dairy products include the Soviet Union, South-east Asian nations, OPEC nations, and some countries in Latin America and Africa.

The EC is also a large importer of butter and cheese, although on net they are a large exporter of these products.

2.4c: World Prices for Dairy Products

Figure 2-5 shows the international prices for dairy products. Prices were recorded at Rotterdam, the Netherlands, the largest single site for dairy shipments.



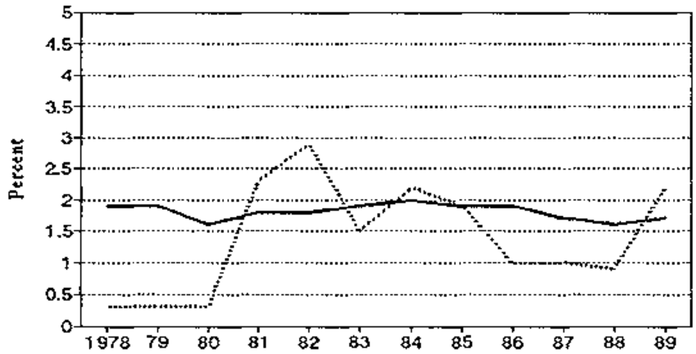
Prices for dairy products hit historically high levels in 1988, but have since fallen considerably. Butter prices have become particularly weak since early 1989, while cheese prices remained firm throughout 1989 before weakening in 1990. Prices for skim milk powder, which reached record levels in 1988 due to low stocks and supplies, levelled off in 1989 and have weakened considerably since as demand has fallen (IDA, 1989).

2.5: The US as a Dairy Exporter - A Review of the Literature

2.5a: Introduction

As this chapter has shown, the EC and New Zealand are currently the only major contributors to world dairy exports. The US has played a role as an occasional exporter whenever it was necessary to reduce domestic surpluses of dairy products, especially butter and skim milk powder. However, US dairy trade has traditionally been relatively small when compared to total production, as Figure 2-6 shows.

Figure 2-6: US Dairy Trade
As a Percent of Domestic Production



Source: USDA Dairy Situation and Outlook

One issue which is currently being discussed is whether the US could play a larger part in exporting dairy products, and what effect the use of bST could have on increasing the potential of the US to become a larger dairy exporter.

2.5b: Review of the Literature

The question of whether the US could become a major dairy exporter was discussed in a paper by Blayney and Fallert (1989). This paper was a follow-up report of an earlier report by Fallert, et al (1987). Blayney and Fallert concluded that, assuming no changes in the current GATT rules, the US could emerge as a significant player in the world market, despite its almost total absence in the past.

Blayney and Fallert's paper listed three major factors which would determine the role of the Americans as dairy exporters. The most important was maintenance of EC production quotas to keep international prices strong. The domestic dairy policy was listed as next important, and third was the use of bST in the U.S. and other dairy trading nations. (Blayney and Fallert, 1989)

A flexible US support price which accommodates domestic supply and demand relationships, coupled with EC discipline in production and export subsidies, would allow the US to be an occasional dairy exporter, according to Blayney and Fallert. With bST in the US, EC-12 discipline and flexible supports, the US would become a commercial exporter more frequently. The reduced costs of milk production, along with additional output in the US resulting from bST use, would more often result in US domestic prices at or below the world price, allowing for more American exports. The US export position is further enhanced if, under the same scenario, American farmers adopt bST while the Europeans and New Zealanders do not (Blayney and Fallert, 1989). They conclude that the current international prices offer trade opportunities for the US, although the continuation of these prices is largely dependent upon EC policy.

Blayney and Fallert also assert that with or without bST, "...dairy price supports determine the relationship between the U.S. domestic dairy product prices and the international prices." (Blayney and Fallert, 1989)

The analysis by Blayney and Fallert, however, did not include any references to trade situations for the US if a rigid price support system is put in place of the 1985 Farm Bill's flexible pricing system. Because their report was written before the passage of the 1990 Farm Bill, their work assumed that increases in production would trigger automatic reductions in the support price. In reality, the 1990 Farm Bill will not do that, instead, farmers will face the same support price through 1995, but would be assessed directly on increases in production.

2.6: Summary

This chapter has provided an overview of the US dairy industry, including the dairy policy of the US government. The chapter discussed that US dairy industry is largely characterised by competitive "family" farms, and farmers' production decisions are largely influenced by government programs. The two major programs are the Federal Milk Market Order Program and the Price Support Program. The price supports, in particular, were fundamentally altered in the 1985 Farm Bill and again in the 1990 Farm Bill. The current policy of a guaranteed minimum price for milk through 1995 was set partly in anticipation of an unsuccessful conclusion to the GATT negotiations. No previous studies have examined how this new legislation would affect producers' decisions regarding adoption of bST.

This chapter has also examined the world dairy policy environment. It discussed the large role the government plays in the dairy industry of most developed nations, and compared the magnitude of government intervention in various countries. The chapter paid particular attention to the contrasting policies of the EC and New Zealand, the most important participants in the world dairy market today.

The chapter then described the current situation and recent trends in the world market for dairy products. The most notable trends were the high prices for dairy products in 1988-89 caused by low supplies, which followed a period of oversupply and low world prices in the mid-1980's. Those high prices, however, have now subsided.

Finally, the chapter discussed what factors would be needed for the US to emerge as a major exporter of dairy products. A previous study had examined this issue, and found that bST could indeed be a major factor in making the US a major player in international dairy trade. That study, however, had been based on the policies of the 1985 Farm Bill. The passage of the 1990 Farm Bill has altered some of the assumptions upon which that study was based.

Chapter 3

An Overview of BST and Its Impacts

3.1: Introduction

Because the primary focus of this study is the impacts of bST on the US dairy industry, it is essential to have an understanding of bST and its effects, especially its economic effects. This chapter begins with a brief description of bST, and the controversy that surrounds it. The latter part of the chapter is a review of the literature of the economic impacts of bST on the US dairy industry.

3.2: An Overview of BST

3.2a: Introduction

The emergence of synthetic Bovine Somatotropin (bST) is one of the most widely discussed advances in biotechnology. BST is a protein which is produced naturally by cattle. Recently developed technology makes it possible for farmers to inject their cattle with synthetic bST at reasonably low prices. Dairy cows which are given daily injections of bST will immediately produce more milk, with no apparent harm to cow health or milk quality. The amount of additional production has not yet been determined conclusively, but experimental results show an increase in milk yields of 10 to 20 percent in cows which were administered supplemental bST (Animal Health Institute, 1988). To gain the full benefits of bST, however, most farmers will have to feed and manage their cows more precisely than they do at present.

Aside from increased herd management and the cost of the bST itself, estimated to be about $US 0.25 per dose, few additional capital or operational outlays will be required. Thus bST will be available to virtually all producers (Fallert et al, 1987).

3.2b: The Controversy Over BST

Despite the benefits of bST, or perhaps because of them, it has sparked considerable controversy. Because bST allows farmers to produce considerably more milk from the same number of cows, it has prompted cries that it will fundamentally restructure the current dairy industry wherever it is adopted. Some argue that dairy surpluses, a chronic problem of the early 1980's will reappear. Others believe that small and medium sized dairies will not be able to compete with their larger counterparts, which will drive many family farmers out of business. Many economists, however, believe that bST will reinforce, not fundamentally alter, current dairy structure and trends (Marion and Wills, 1990). Furthermore, in this age of growing public concern over chemicals in food, bST-treated milk may be rejected by consumers, even if governmental regulatory agencies regard it as safe.

These concerns have prompted some dairy producer groups and consumer advocates to call for a ban on the use of bST, even before it has been made available. In the EC, a ban has been proposed, and adoption, at least in the foreseeable future appears unlikely. New Zealand has adopted a "wait and see" attitude, to gauge the effects of bST in other counties before beginning adoption. While these two major dairy exporters hedge on the use of the new technology, the U.S. could arise as the only major dairy producer to use bST in the early 1990's. This could place the Americans in a position to produce more milk more cheaply, and increase exports at the expense of the EC and New Zealand.

3.2c: Use of BST in the United States

The U.S. is in probably the best position of any dairy producing nation to take advantage of bST, because of current policy and production practices. Unlike many OECD countries, the U.S. does not impose production quotas for milk. In countries with quotas, there is little incentive to adopt new technology if the farmer has to maintain quota levels.

Although New Zealand does not impose quotas on milk production, bST's effectiveness there would be hampered by the constraints of New Zealand's pasture-based production system. American dairy production, in contrast, uses a combination of concentrates (grains) and forages. The American system allows for more flexibility in feeding and an increased ability to meet the nutritional challenges presented by bST than New Zealand's pasture-based production system (Blayney and Fallert, 1989).

Even in the U.S., however, future use of bST is in doubt. The states of Wisconsin and Minnesota, which produce 25% of the nation's milk, recently passed a temporary ban on bST use. Western United Dairymen, a dairymen's association based in California, called for an industry imposed moratorium on bST. The proposed moratorium would remain in effect until there is sufficient evidence that bST would not adversely affect milk sales (Dickrell, 1990). However, there has been no Congressional action to ban the chemical nationally in the U.S.

The U.S. Food and Drug Administration (FDA), which must approve bST for production and use in the U.S., was expected to approve it in early 1990. However, the sheer volume of data submitted to the FDA concerning the effects of bST has forced the agency to delay approval. To gain FDA approval, a drug must be found to be safe and effectual. BST's effectiveness has been determined, and it has been ruled as being Generally Regarded as Safe (GRAS) for both humans and cattle. Further studies, however, are being conducted at present to determine conclusively if there is any long term detriment to animal or human health. General expectations are for these tests to be concluded in late 1991. FDA approval could follow in early 1992. Even with FDA approval, however, bST use could be blocked by industry or government action.

3.3: The Impacts of BST: A Review of the Literature

3.3a: Introduction

The effects of bST use has been a widely discussed topic in agriculture in recent years. This section reviews selected papers which concern bST and the economic impacts it could have, especially in the US. Many of the papers which have been written about bST concern its effects on cow health and milk production under various circumstances. While these studies are important in investigating the effects of bST, they are not the main topic of this study, which is concerned with the economic implications the use of bST. Therefore, this section will focus on papers which have attempted to gauge the economic impacts of bST on the American dairy farmer.

3.3b: An Overview of the Literature

Three recent studies which have estimated the impact of bST on the US dairy sector are given particular attention in this chapter. These recent studies have consistently concluded that the economic impacts of bST, while significant, will not be as great as previous studies had suggested. These three papers, in order of their publication, were written by Fallert, et al; Marion and Wills; and Kaiser.

Another recent paper, by Tauer and Kaiser, attempted to determine the optimal government dairy policy that should be implemented if bST is approved. This study is discussed later in this section.

Fallert et al (1987) concluded that the effects of bST on the dairy industry would be less dramatic than had been previously thought and that the economic impact of bST would depend to a large extent on the flexibility of the price support program. The paper added that bST would tend to reinforce, not fundamentally alter, structural changes already underway in the dairy industry. Furthermore, they found that bST would likely have little effect on the US position in the international dairy market under 1987 trade policies.

Marion and Wills (1990) study of bST use in Wisconsin agreed with Fallert et al that bST would have a less dramatic effect than previous studies had indicated, but would still lead to a significant increase in national milk production. They also approached the question from a different way than Fallert et al. Fallert assumed certain levels for bST costs, response rates, and adoption rates, and from these assumptions predicted total increases in milk production in the US. In contrast, Marion and Wills looked at various possible response rates and possible costs for bST, and from those predicted the adoption rate of bST in Wisconsin. Like Fallert et al, Marion and Wills caution that their results are sensitive to several assumptions, such as production response rates, which are still controversial.

Kaiser (1990) concluded that without bST, US milk production would decline from 1990 to 1995, but with bST milk production would rise while prices would fall. The result was reduced farmer incomes as a result of bST use. Kaiser based the assumptions for this study on the averages of several previous studies, including Fallert et al and Marion and Wills. Like these other studies, Kaiser cautions that changes in any of the several assumptions about bST's effect will have a dramatic impact on the results obtained. Table 3-1 summarises some of the assumptions that were made by the authors of these three papers.

Table 3-1: Parameters Assumed in Previous BST Studies

Study	% Increase in Milk per Cow	Annual Cost of BST ($/cow)	Adoption Rate (% of farmers using bST) 1991	1992	1993	1994	1995
Fallert et al	13.5	50.4	10	20	36	44	48
Marion & Wills	9, 12, 15	52.5, 85					
Kaiser	14.3	55.7	9	19	35	54	60

3.3c: A Closer Look at the Assumptions

It is important to look at the underlying assumptions in these and other studies, because many of these assumptions remain controversial. The most commonly discussed topics regarding bST fall roughly into five categories: the safety of bST to cattle and people; consumer response to bST treated milk; yield response per cow from bST use; and adoption rate by farmers.

Numerous studies have been conducted on the safety of bST to cattle and humans. None has conclusively shown that there are any short or long term health risks from bST, either to cattle treated with bST or to people who drink milk from these cows. The US Food and Drug Administration (FDA) have concluded that milk and meat from bST-treated cows is safe. Even when ingested into the human bloodstream, bST is inactive, and the bST protein is easily digestible (Apostolou, 1988). Barbano and Lynch (1988), in a study on milk composition, concluded that there is no difference between the milk from bST-treated and untreated cows. Numerous studies published in recent years have studied the effects of bST on cattle health in different areas and under various conditions. None has found any significant adverse effects to cattle health (Journal of Dairy Science, 1988-89). Most recently, a study by the National Institute of Health concluded that there were no adverse effects to humans or cattle from bST. Therefore, most studies assume that the FDA will approve bST soon.

Another highly controversial issue concerning bST is consumer acceptance of milk treated with bST. Numerous studies have noted that milk from bST-treated cows may be rejected by consumers, even if it is approved by the FDA. However, there has been a lack of conclusive research into this area, simply because consumer response is difficult to measure ex ante. Fallert et al and other studies from the USDA have assumed that if bST is approved as safe by the FDA that it will be accepted as safe by the general public.

An important factor in determining the effect of bST on milk production is the yield response rate per cow from bST treatments. Several studies have attempted to determine the response rate, but their conclusions remain controversial. It is still not clear whether bST gives a proportional (e.g. 15%) or constant (e.g. 10 pounds/day) increase in milk production, or a partly constant and partly proportional response. The age of cows may also be a factor in the response rate. Fallert et al assumed a constant response rate of 8.4 pounds/day, which they equated to a 13.5% increase over current cow production. Marrion and Wills (1990) used three levels of proportional responses (9%, 12%, and 15%), a constant rate of 1,800 pounds/year, and a mixed response of 900 pounds per year plus 6% of base production. Other studies, cited by Kaiser, used proportional response rates of 10, 15, and 20 percent. Kaiser used the average of all these studies, which was 14.3%

The other determinant of bST's effect on milk supply is the rate at which farmers adopt bST. Studies have been conducted in several states to determine the rate at which farmers in those states would adopt bST. Fallert et al assumed a gradual rate of adoption for US farmers with about 10% adopting it in the first year it becomes available and increasing up to a 50% adoption rate five years after it is introduced onto the market. This rate is consistent with studies done in California, Minnesota, and Michigan (Fallert et al, 1987). The adoption rate used by Kaiser, again based on several previous studies, were also similar to those in Fallert et al, although slightly higher.

All these studies agree that the adoption rate is also dependent upon the farm milk price and on the cost of bST. In most studies, various milk price scenarios were assumed, most of which assumed that an increase in production which led to government removals of over 7 billion pounds would automatically trigger a reduction in the dairy support price. This was the case with the 1985 Farm Bill, which set dairy policy in the US from 1986-1990. However, the 1990 Farm Bill, which set the policies for 1991-1995 does not contain this provision and has set a guaranteed minimum support price of $10.10/cwt. regardless of anticipated surpluses.

It is more difficult to speculate as to the price of bST, since the price will be determined by the market after it is approved. However, Fallert et al (1987) assumed a price of $0.24 per day per cow. Marrion and Wills (1990) used a range of prices from $0.25 to $0.40 per day. Kaiser found an average price from previous studies of $.55 per day.

3.3d: BST and Optimal Government Policy

In a recent study, Tauer and Kaiser estimated a discrete control model of the US dairy sector to determine the optimal dairy policy the government should implement if bST is made available (Tauer and Kaiser, 1991). The optimal policy was defined as that which maximises social welfare, which is producer and consumer surplus less adjustment and net government costs. A variable (declining) support price and a cow buyout program, similar to the DTP, were used as control variables. The bST adoption rate was determined endogenously, based on the profitability of bST. A response rate of 13.5% was assumed (Tauer and Kaiser, 1991).

The study's results showed that the shock of the introduction of bST could be reduced if a declining support price and a cow buyout program were implemented. While the empirical results show that milk prices and farm profits declined after the introduction of bST, these reductions were not as severe when compared to other studies where government policies and adoption rates were determined exogenously.

Furthermore, the annual adoption rates were lower than those from previous studies, suggesting that the adoption of bST will be slow and incomplete. The results also showed that if a cow buyout program is put into effect, CCC purchases of surplus dairy products would be minimal because the cow removals would curtail the milk supply.

The authors caution, however, that the model's results are determined using a declining support price, unlike the one currently in use. There are also currently no provisions for a dairy buyout program.

3.4: Summary

This chapter has discussed the impacts of bST, and reviewed the literature of the effects of the adoption of bST in the US. The first part of this chapter explained that bST is a naturally occurring hormone which has now been reproduced synthetically, and may be able to increase milk production in dairy cows by as much as 20%. That section also explained that bST has not been approved for use in the US or any other developed nation, and that bST remains controversial because of both its possible impacts on health and on the structure of the dairy industry. The final part of the section discussed why bST was more likely to be approved and adopted in the US than in the other developed countries.

The latter part of this chapter reviewed some of the recent literature of the economic impacts of bST use in the US. The review focused primarily on three papers, all of which concluded that the effects of bST would be significant, but far less than previous studies had suggested. All three of these papers also cautioned that their results were sensitive to several underlying assumptions which are still controversial. These include assumptions concerning bST's safety, consumer acceptance of bST-treated milk, the milk yield increase per cow from bST (response rate), and the number of farmers who adopt bST (adoption rate).

Another study which was reviewed suggested that an optimal government policy for the dairy sector after the introduction of bST would likely include the implementation of a declining support price and a cow buyout program.

Chapter 4

A Conceptual Model of the Impacts of BST

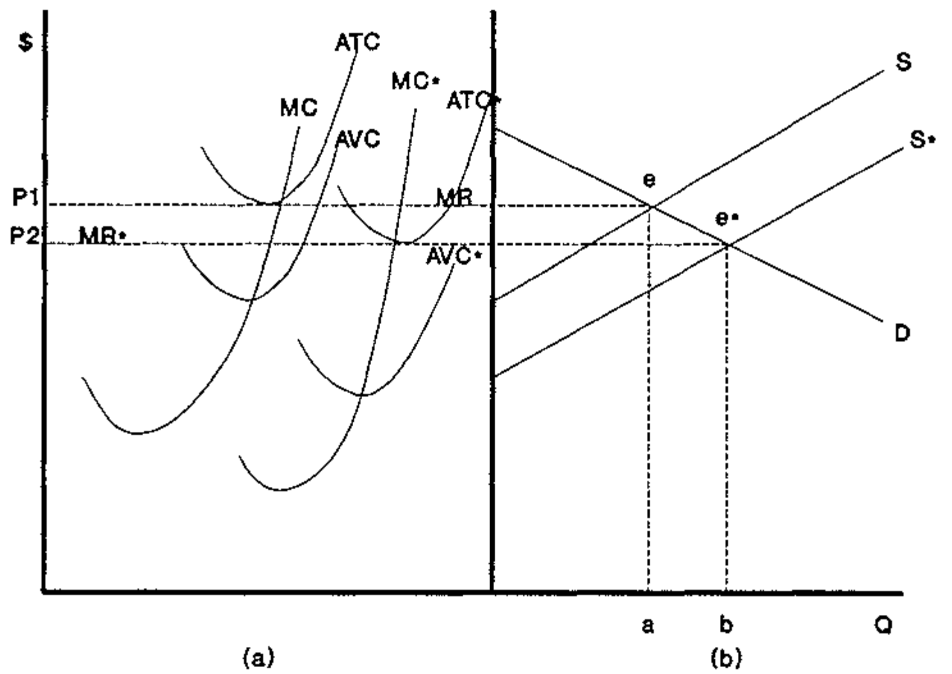
4.1: Introduction

Previous chapters have explained the current policy environment in the US dairy industry, and the possible impacts of bST. This chapter will use economic theory to develop a conceptual model of the impacts of bST on the US dairy industry under current policy. The chapter begins by discussing the impacts of the introduction of a new technology in a perfectly competitive industry. This model is then modified to account for government intervention in the industry. Since bST use in the US could affect the international market, the model also looks at those effects as well. In particular, this chapter discusses the effects of using an export subsidy to dispose of excess domestic supply on the world market.

4.2: The Effects of Adopting a New Technology

Figure 4-1 illustrates the impact that a cost-reducing technology, such as bST, would theoretically have on a perfectly competitive industry. Panel (a) shows the cost curve of a typical firm while in panel (b) the market demand and supply situations are shown. Assume the market is originally at equilibrium. At that point a profit-maximising firm would produce where their marginal cost (MC) is equal to their marginal revenue (MR). The marginal revenue would be the same as the equilibrium market-clearing price, where supply equals demand, which is P1. Assuming this industry is in long-run equilibrium, the firm's minimum average total cost (ATC) also equals MR. The minimum ATC is also the point on the ATC curve that intersects the MC curve. Total revenue, which is the quantity produced multiplied by the price per unit, is exactly equal to total cost.

Figure 4-1: Effect of Adopting a New Technology



The firm will produce, at least in the short run, at any point on the MC curve above the point where it intersects the average variable cost (AVC) curve. The aggregate supply curve, S, is therefore represented by the MC curve above the AVC curve.

Now assume that a new cost-reducing technology, like bST, is introduced. The firms that adopt the technology will be able to produce the same quantity as before for a lower cost. Another way to think of this is that the firm can produce a greater quantity at the same cost as a smaller quantity used to cost.

The effect of the technology is to shift the MC curve to the right. Since the supply curve is derived from the MC curve, the supply curve also shifts to the right to form S*. The demand curve, D, does not shift because demand is based on consumer utility which has not changed in this example.

The equilibrium price falls to e*, the intersection of S* and D. Total output increases from Points a to b. The lower equilibrium price, P2, means the MR line also falls to the same lower level, creating MR*. Thus, the firm will shift production to the point where MC* = MR*.

In the long run, all the firms in the industry will adjust their output to the intersection of MC* and MR*. In the short run, however, prices may adjust slowly. Thus, some firms that adopt the technology early may be able to produce on the new MC* curve where it intersects the original MR curve. At that point, the firm's total revenues exceed its total costs, and the firm makes a pure profit, or rent. In time, more producers will adopt the technology, increasing the supply of the good, until the price falls to P2, where the industry reaches a new long run equilibrium.

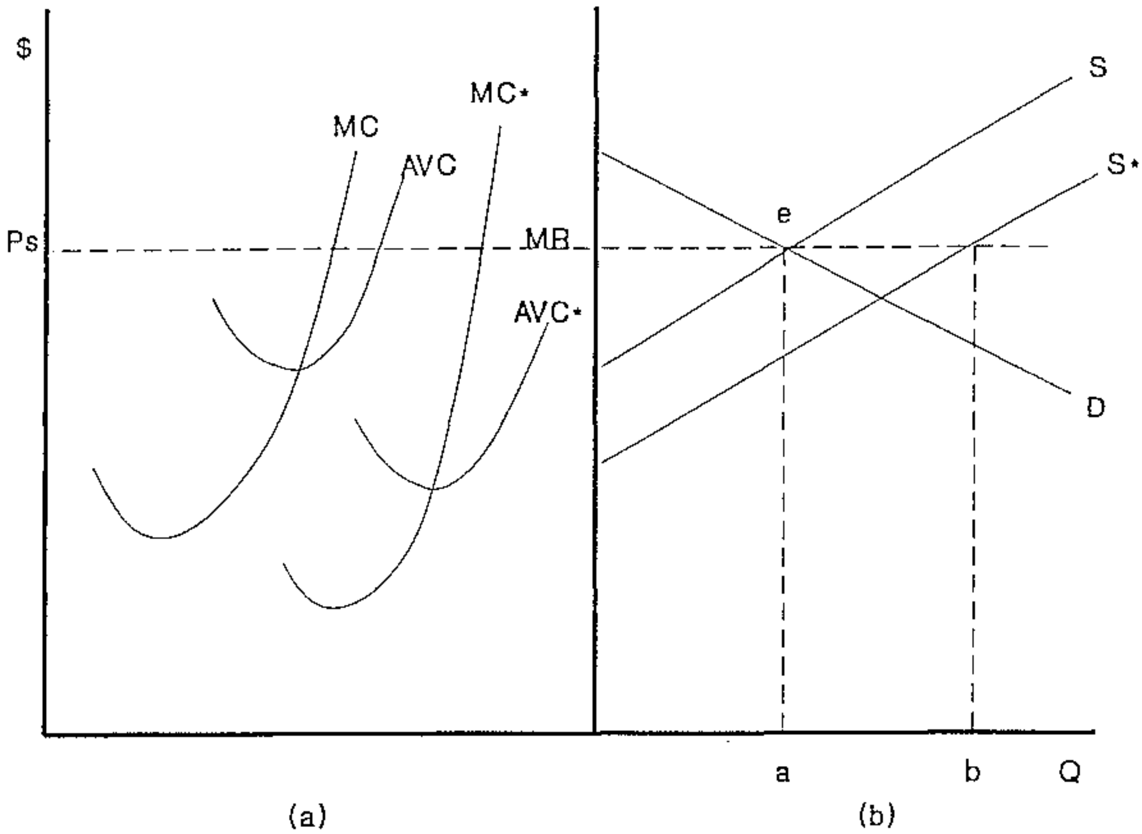
4.3: Effect of a Support Price

As an earlier chapter explained, the US government sets a specified minimum level for milk prices. If the price farmers receive for milk falls below this minimum, a government agency will purchase dairy products and remove them from the market. The government removals reduce the supply of dairy products, which raises the milk price at least as high as the guaranteed support price.

Because of the support price, the model of the effects of a new technology shown above must be adapted to make it more accurately reflect the actual effects on the US dairy industry. Figure 4-2 illustrates the effect of a support price as a new technology is adopted.

Figure 4-2(a) is similar to Figure 4-1(a). Again, the industry begins at a long run equilibrium, and for the purposes of this illustration it is assumed that the long run equilibrium price is equal to the support price (Ps). As in the above model, the adoption of the technology shifts the firm's marginal cost curve to the right, to MC*. This also shifts the supply curve to S*.

Figure 4-2: Effect of a Support Price As a New Technology is Adopted



Because the price is supported by the government, however, the price does not fall to a lower level to reach a new equilibrium. Instead, the price remains at Ps. At price Ps, the farmers who have adopted the new technology will supply quantity b, but consumers will only demand quantity a. Therefore, there is an excess supply of quantity (b-a). This excess quantity, under the current policy, must be bought by the government and removed from the market. The government removals effectively shift the supply curve back to the left until equilibrium is regained at its original point, e. The total purchasing cost to the government is (Ps * (b-a)), which is equal to the unit purchase price (the support price) multiplied by the quantity purchased.

4.4: Export Subsidies

4.4a: Overview of Export Subsidies

The purchase cost is not the only expense the government incurs in supporting the milk price. The government must also store and dispose of the dairy products it has removed from the market. Much of the government stocks will be sold on the international market or donated to poor countries as food aid. The effect is a greater supply of dairy products on the world market. In other words, the US will shift its excess supply of dairy products to the right, increasing the world's total excess supply.

Because the support price in the US is almost always higher than the world price, the government will usually have to subsidise the exports. An export subsidy is a direct per-unit payment the government gives an exporter on the volume of goods cleared for foreign destinations (Hallett, 1981). In other words, the stocks are sold overseas for less than the purchase price (the support price), and the government absorbs the loss on the difference.

The government can also provide indirect export subsidies by allowing marketing agencies to act as monopolies which may purchase goods domestically and have monopoly rights to sell on the international market. Such an agency would effectively be using an export subsidy if it purchased a good at a higher price domestically than it sold the good for on the world market (Hallett, 1981).

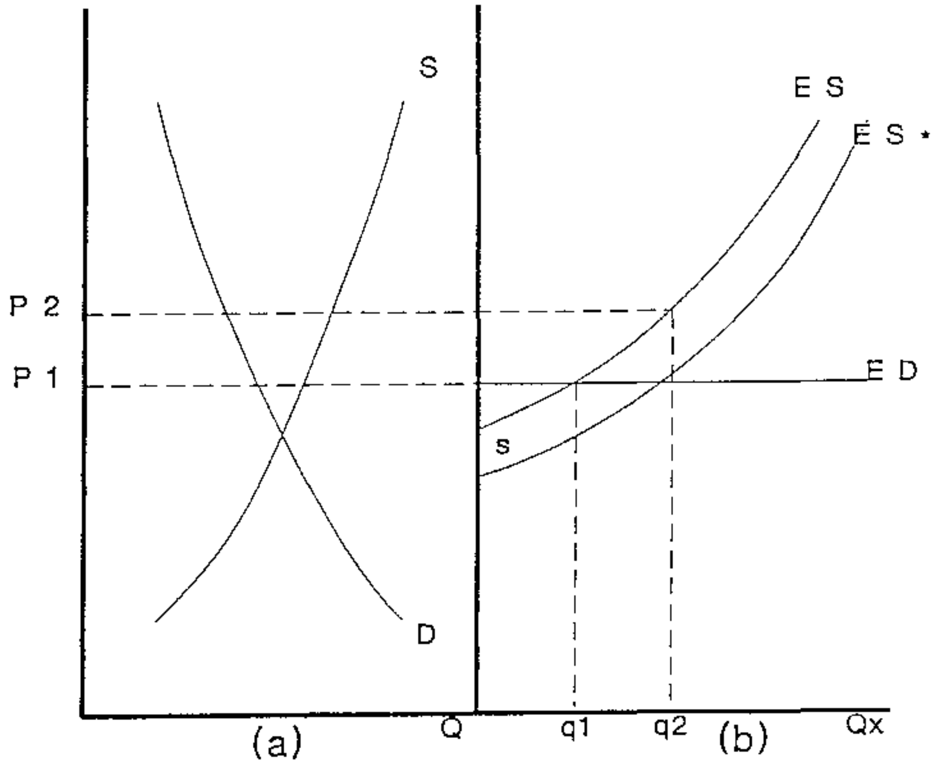
Export subsidies may be for a fixed amount, or the subsidy may be allowed to fluctuate. The next sections discuss an example of each type.

4.4b: Effects of a Fixed Export Subsidy: A Small Nation Example

If the export subsidy is for a specific per-unit amount, then the domestic price will rise above the international price by the amount of the subsidy. This is illustrated in Figure 4-3. The figure assumes the export volume is relatively small compared to total world exports, and the increase in exports from this country will not affect the world price. Therefore, the exporting country faces a perfectly elastic excess demand curve, and can sell all of its excess supply for the given world price, P1. The exporter's quantity of excess supply is the difference between the quantity demanded and the quantity supplied on the internal market (4-3a) at price P1.

Figure 4-3: Fixed Export Subsidy

Small Exporter Example



Assume the government offers a fixed export subsidy equal to the vertical distance s in Figure 4-3b. The subsidy lowers the supply price of exports by the amount of s per unit, giving a new excess supply curve faced by overseas buyers of ES*. The new equilibrium is at the intersection of ES* and ED, an increase in export volume of quantity (q2-q1). Exporters, eager to earn subsidy payments, expand export sales and bid up the internal price to price P2, although the international price remains unchanged. The increased domestic price cuts domestic consumption and expands domestic production, and therefore the quantity available for export is increased. The cost to the government of providing the subsidies is the per-unit subsidy, s, multiplied by the new quantity exported, q2.

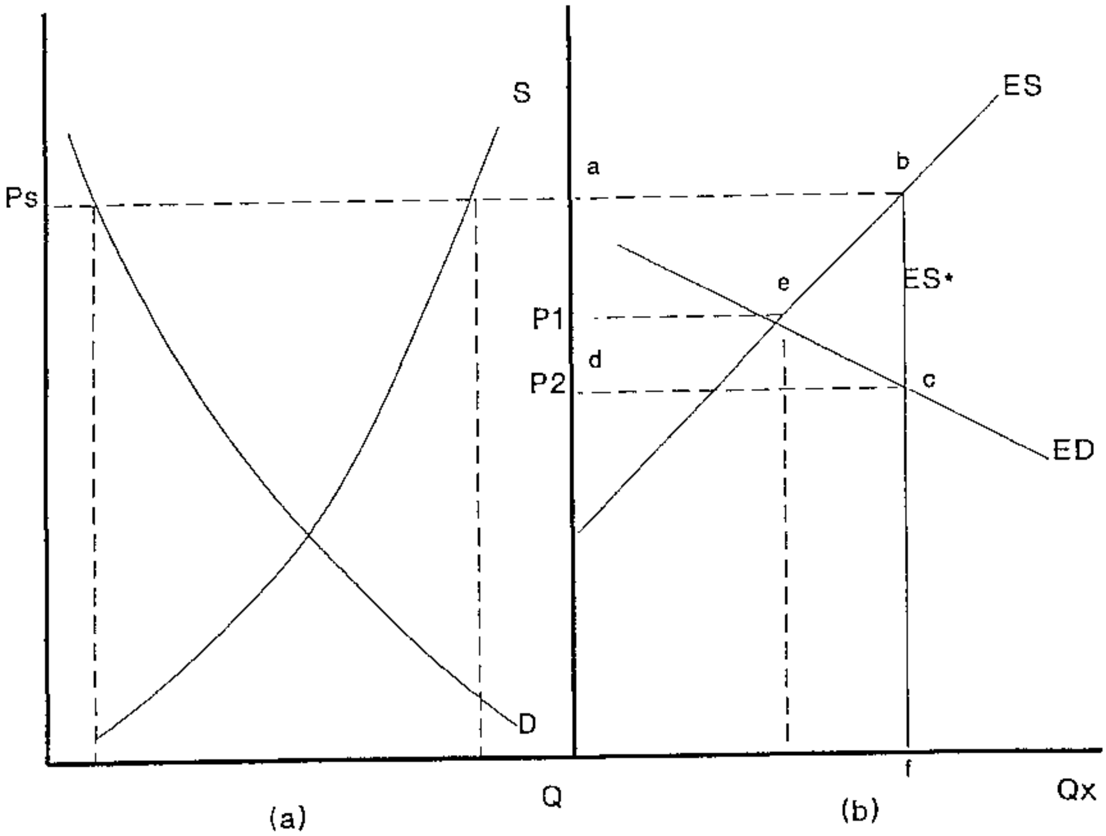
4-4c: A Variable Export Subsidy: A Large Nation Example

The actual use of export subsidies by the US is more accurately represented by a variable export subsidy than by the simpler fixed subsidy example shown above because a variable subsidy disconnects the domestic price from the world price and allows the government to maintain an internal support price (Hallett, 1981).

Figure 4-4 shows the effects of a variable export subsidy used by, in this case, a large exporting nation. Unlike the example above, this nation faces a downward sloping excess demand curve, ED in panel (b), because increased quantities from this nation are large enough to decrease the world price.

In the domestic market, the government guarantees a domestic price at price Ps in panel (a), which is considerably higher than the world price, P1 in panel (b). At price Ps, the quantity supplied on the domestic market exceeds the quantity demanded, creating an excess supply. Because the price is supported domestically, the excess supply curve is the vertical line ES* for any international price below Ps.

Figure 4-4: Variable Export Subsidy
Large Country Example



At price Ps, the exporter would like to export quantity f, but the rest of the world will only purchase that quantity at the much lower price of P2. To move the volume of exports needed to maintain the domestic support price, the government may offer an export subsidy of the vertical distance bc. The cost to the government is the area abcd, which is the difference between the support price, Ps, and the new world price, P2, multiplied by the quantity exported, f.

The effect of such an export subsidy by a large exporter to maintain a domestic support price is readily apparent. The world price in Figure 4-4b has fallen from P1 to P2 as a result of the increase in the subsidised exports. This price fall reduces the export revenues of other exporting countries. Those other exporters are also likely to accuse the subsidising nation of unfair trade, and may retaliate in some way.

Another apparent result of the subsidy is the cost to the subsidising nation. If the quantity subsidised and/or the amount of the export subsidy is large, then the cost to the consumers and taxpayers could be quite high. Such is the present case in the EC, and to a lesser extent in the US.

4.5: Developing a Model of the Effects of bST

4.5a: Overview

The above sections of this chapter have shown how the effects of the adoption of bST and the current policy environment are represented by economic theory. The next step is to develop a reasonable and reliable empirical model of the US dairy industry that is compatible both with economic theory and the known structure and policy of the industry . That model, assuming it can be validated, can then be used for forecasting, and the expected effects of bST can be incorporated into the forecasts.

4.5b: Models of the US Dairy Industry - A Review of the Literature

Before developing a model of the US dairy industry, it is instructive to first review some of the previous work that has been published in this field. In particular, this section will focus on two papers which developed models of the US dairy industry. One was written by Wescott and Carman (1985) of the USDA. The other was written by Kaiser (1990) of Cornell University.

Wescott and Carman (1985) presented a quarterly econometric model of the US dairy industry, which consisted of a nine equation model. The model estimated equations for milk cow inventory, milk production per cow, commercial milk use, and farm milk price. Identities were used to find milk production, milk marketings, total milk supply, government removals of milk, and the effective milk price. The model was then used to forecast production, prices, and government removals under various policy scenarios.

They found that a support price which remained unchanged from its 1984 level of $12.60/cwt. would increase government removals by over a billion pounds in two years, due to a 4% increase in production. In contrast, a gradual drop in support prices to $11.60/cwt. would cut government removals by nearly a billion pounds, as the reduced price raised commercial milk use while production remain largely unchanged. Their third scenario consisted of a sudden fall in the support price to $10.00/cwt. This created a 60% drop in government removals (from 7.5 billion pounds to 3 billion pounds), a 13% drop in farm milk price, and a 4% increase in commercial demand, but only a very small fall in production.

Wescott and Carman's model was developed just prior to the passage of the 1985 farm bill, which significantly altered the US dairy price support system. The provisions of the 1985 Farm Bill closely resembled the second scenario described above (a gradual reduction in support prices to $11.60/cwt.), and the actual effects that it caused were similar to the ones predicted by Wescott and Carman.

Kaiser (1990) developed a 10 equation annual econometric model for the US dairy industry. Unlike Wescott and Carman, Kaiser distinguished between fluid milk and milk for manufacturing. In addition to milk cow numbers and production per cow, the model also estimated equations for supply, demand, farmgate prices, and retail prices for both fluid milk and milk for manufacturing. The model then used identities to derive total milk supply, total demand, farm and retail balance, and government removals of milk.

Kaiser then used the model to predict the results of two scenarios, which show the impact bST would have on the dairy industry between 1990 and 1995. Both scenarios assumed that support price levels will be linked to government removals, meaning that the support price would fall if government removals were above a specified level. The first scenario, which assumed that bST was not used by farmers, indicated that support prices would fall to $9.10/cwt by 1991, leading to a quick reduction in cow numbers and a fall in total production, and virtually no government removals after 1993. The other scenario made all the same assumptions as the first, except it allowed the use of bST. The result was that cow numbers declined even more rapidly, but were offset by markedly higher production per cow, so that total production actually increased. This created much higher levels of government removals than in the first scenario.

As was discussed above, the 1990 Farm Bill (which was passed after Kaiser's article was published) will maintain support prices at $10.10. Kaiser's scenarios, however, allow support prices to stay below $10.10 for four consecutive years in his predictions for 1990-1995.

4.6: Summary

The first part of this chapter was devoted to illustrating the economic effects of the adoption of bST. It also showed how the impacts of bST would be influenced by the current US dairy policy, especially the support price. The section also showed the impacts of an export subsidy, which would likely be used to dispose of an excess supply of milk in the US caused by the support price and bST.

The latter part of this chapter began the process of developing a model of the US industry. The model would need to be compatible with economic theory and a priori reasoning of the effects of current policy and the current structure of the industry. Such a model could then be used as a forecasting device, and could incorporate the effects of bST into its forecasts.

The first step in developing such a model is reviewing the literature of publications which have done similar work. Two such papers were reviewed which developed econometric models of the US dairy sector. Both papers used multiple equation econometric models which explained supply, demand, and prices for milk in the US. Both models were then used for forecasting. The model by Kaiser incorporated the effects of bST into the model's forecasts using many of the assumptions of bST found in works which were reviewed in the previous chapter. The forecasts for both models, however, were based on the assumption that the policies of the 1985 Farm Bill would be extended into the 1990's. As a previous chapter mentioned, the 1990 Farm Bill changed many of the support price policies upon which these studies relied.

Chapter 5

The Econometric Model and Empirical Results

5.1: Introduction

Since the objective of this paper is to measure the effect that bST use in the US will have on the US dairy industry, and the subsequent implications for international dairy trade, an economic model of the US dairy industry is an essential part of this study. This chapter discribes the model that was used in this study and explains why this particular model was chosen. The empirical results are presented and discussed. The next section of this chapter validates the model and uses it to generate forecasts through 1995. The next chapter will show how the adoption of bST was included into the model, and the results that were obtained.

5.2: The Dairy Simulation Model

5.2a: Overview of the Model

This study uses an aggregate quarterly econometric model of the US dairy sector in order to determine the potential changes in total milk production in the US as a result of the adoption of bST. A quarterly model was chosen to account for the highly seasonal changes in supply and demand for milk.

The analysis is done in the following stages:

(1) determine appropriate econometric models for the relevant variables under consideration

(2) simulate these models to generate out of sample

forecasts for the relevant variables

(3) use the predicted values to estimate the potential increases in milk production from bST.

The econometric model consists of four behaviourial equations that explain milk cow inventories, milk production per cow, commercial milk disappearance (a measure of milk demand), and real farm prices for milk. Total milk production is derived through an identity, which is the product of milk per cow and cow inventory. The model is estimated using quarterly data for the period starting in the first quarter of 1981 (1981.1) through the first quarter of 1990 (1990.1).

5.2b: Data Sources and Estimation Procedures

The definitions and units of the variables used in the dairy simulation model are given (in alphabetical order) in Table 5-2. Most of the data was obtained from the monthly USDA Dairy Situation and Outlook Reports from 1981-1990, including the data for commercial disappearances, cow inventory, milk production per cow, and the effective support price. The soybean meal price was found in the USDA Oil Crops Situation and Outlook Reports from 1981-1990. The data for US disposable income was taken from the USDA Agricultural Outlook, 1981-90. All the price series data were deflated by the consumer price index (1967=100), which was also obtained from Agricultural Outlook.

Because the explanatory variables in some equations are themselves determined by other equations, two stage least squares (2SLS) was used as the estimation technique. The estimated econometric equations are summarised in Table 5-1 followed by a list of the variable definitions in Table 5-2.

All variables are specified in their logarithmic form except for the 0-1 dummy variables which are in non-log form. Also, real prices, which are deflated by the Consumer Price Index are used. This is in keeping with generally accepted economic theory that decisions by producers and consumers are based on real prices rather than on nominal prices.

Table 5-1: Econometric Equations of the Quarterly Dairy Model: 2SLS Results 1981.1 - 1990.1

1. Cow Inventory

$$\ln COW = \underset{(3.4)}{1.24} + \underset{(22.0)}{0.87} \ln COW_{-1} + \underset{(4.3)}{0.05} \ln RFMP_{-1} - \underset{(-4.0)}{0.02} \ln RBMP_{-1}$$

$$- \underset{(-5.2)}{0.015} DTP - \underset{(-3.5)}{0.009} D1 - \underset{(-2.5)}{0.006} D2 - \underset{(-0.76)}{0.002} D3$$

$R^2 = .98$; DW = 1.7; F = 236; CV = 0.056

2. Milk Production Per Cow

$$\ln MPC = \underset{(2.0)}{2.02} + \underset{(5.8)}{0.73} \ln MPC_{-1} + \underset{(2.0)}{} \ln RFMP_{-1} - \underset{(-1.9)}{0.05} \ln RBMP_{-1}$$

$$+ \underset{(2.7)}{0.002} T + \underset{(6.4)}{0.05} D1 + \underset{(17.1)}{0.09} D2 - \underset{(-0.4)}{0.004} D3$$

$R^2 = .97$; DW = 1.5; F = 190; CV = 0.14

3. Total Milk Production

$$\ln PROD = \ln COW + \ln MPC$$

4. Commercial Disappearances of Milk (Demand)

$$\ln CDIS = \underset{(9.2)}{8.92} - \underset{(-1.8)}{0.2} \ln RFMP + \underset{(2.1)}{0.26} \ln RY - \underset{(-6.8)}{0.09} D1$$

$$- \underset{(-0.8)}{0.01} D2 + \underset{(1.5)}{0.02} D3$$

$R^2 = .86$; DW = 1.24; F = 44.5; CV = 0.25

5. Real Farm Milk Price

$$\ln RFMP = \underset{(1.8)}{7.1} + \underset{(9.0)}{0.79} \ln RESP - \underset{(-1.7)}{0.72} \ln COW - \underset{(-1.3)}{0.03} D1$$

$$- \underset{(-4.1)}{0.09} D2 - \underset{(-3.1)}{0.07} D3$$

$R^2 = .85$; DW = 0.53; F = 42.0; CV = 3.46

Note: 'ln' preceding a variable denotes the natural log of that variable.
Subscripts at the end of a variable denote a quarterly lag.
T-values are shown in parentheses.
DW is the Durbin-Watson value.

Table 5-2: Variable Definitions for the Quarterly Dairy Model

Variable	Definition	Units
CDIS	Commercial Disappearances of Milk	Million pounds (3)
COW	Milk cow inventory (1)	Thousand head
Di	Dummy variable equal to 1 in the i^{th} quarter. i = 1,2,3	0 - 1
DTP	Dummy variable for the Dairy Termination Program. Equals 1 for 1986-87; 0 otherwise	0 - 1
MPC	Milk production per cow (2)	Pounds
RBMP	Real soybean meal price at Decatur, 44% protein (1)	US$/ton (4)
RESP	Real Support Price, less price deductions	US$/cwt. (4)
RFMP	Real farm milk price, for all milk sold to plants (1)	US$/cwt. (4)
RY	Real US disposable income (1)	Billion $ (4)
T	Time trend	1 - 60

(1) - Average for the quarter
(2) - Sum for the quarter
(3) - Milk equivalent of products
(4) - Deflated by CPI, 1967=100

Judging by their R-Squares, F-values and the coefficient of variation, all equations perform reasonably well. Autocorrelation did not pose a major problem for any of the equations except for the real farm milk price. Correction of autocorrelation in this case created additional problems at the simulation stage.

5.2c: Results and Discussion

Cow Inventory

As is shown in Table 5-1, cow inventory is determined as a function of cow numbers in the previous quarter, real farm milk prices lagged one quarter, real soybean meal price lagged one quarter, a dummy variable (DTP) to account for the Dairy Termination Program, and quarterly seasonal 0-1 dummy variables. This specification is similar to the ones used previously by Kaiser (1990) and Wescott and Carman (1985). All coefficients (except for D3) had the expected signs and were statistically significant at the 0.5 percent level.

Milk Production Per Cow

Milk production per cow was modelled following previous specification by Kaiser (1990). It was found that milk per cow was a function of milk per cow from the previous quarter, the real farm milk price, the real price of soybean meal, a trend variable, and quarterly seasonal dummy variables. As in the Kaiser model, the estimated coefficients had the expected signs and were also significant at the 0.5 percent level. As expected, the production of milk per cow is highly seasonal. In addition, the linear time trend confirms the gradual and steady increase in milk production per cow over the years.

Total Milk Production

The two above equations were used to obtain the total quantity of milk supplied in the US, which is the product of their results. In its mathematical form, using the variable names, this would be written as:

PROD = COW * MPC.

In other words, the total milk production for the US in any given quarter is equal to the number of milk cows multiplied by the average milk production per cow.

Because the dairy simulation model uses logarithmic form, the above equation is written by the equivalent logarithmic form:

ln PROD = ln COW + ln MPC.

Because they determine milk supply, it is important that equations for milk production follow generally accepted supply theory. Theory states that the quantity of a good supplied is a function of the price for the good, which in this case the real farm milk price. Also, the quantity is determined by the price of inputs, which are represented by the price of soybean meal, an important cattle feed. Technological advances are also an important determinant in the quantity supplied. In this model, the trend variable, which increase by one unit every quarter is used to account for technological advances through time. Government programs also help determine the quantity supplied. In this model it was found that the DTP was a significant variable in determining cow numbers, and thus milk supply. Other government programs are indirectly represented in the farmgate milk price, which is supported by the government. The seasonal dummy variables are necessary to account for the seasonality of production, which is largely a result of biological and certain managerial constraints.

Commercial Disappearances of Milk

Commercial disappearances of milk expresses the quantity demanded for milk. In any given quarter, commercial disappearances of milk equals the difference between total production during the quarter and the change in inventory stock levels at the end of the quarter (Dairy Situation and Outlook Report). In this model, the specification of commercial milk disappearance equation follows conventional consumer demand theory whereby the demand for a product is determined by its own price and the level of income. Demand may also be determined by the price of substitutes, but since the equation explains commercial disappearance, which is at the wholesale level rather than at retail, the prices of substitutes become less relevant.

This model gave satisfactory results with the important explanatory variables highly significant. It was thus found that commercial disappearances of milk are a function of real farm milk price, the real US disposable income, and the seasonal dummy variables.

Real Farm Milk Price

An essential element in the above equations is the real farm milk price. Modelling the real farm milk price represented some challenges as the performance of this equation was less satisfactory than the above equations. The real farm milk price is specified as a function of the real effective support price, the dairy cow inventory level, and quarterly seasonal dummy variables. The real effective support price is equivalent to the real support price less deductions. The deductions are levies that farmers paid on each pound of milk they marketed to finance such programs as the DTP. The real effective support price is used because it, rather than the real support price, is the guaranteed minimum price upon which farmers base their production decisions.

Previous attempts to model the real farm milk price by Wescott and Carman (1985) differ somewhat from the current specification. This is partly due to the different time period under consideration, and the structural changes that have occurred in the industry since that study was conducted. The estimated coefficients have the expected signs and apart from one of the seasonal dummy variables (D1) are all significantly different from zero.

5.3: Model Validation

So far, the behaviourial equations of the dairy sector model have been evaluated using statistical tests like the t-test for individual coefficients, and the R-square and the F-test for the significance of the different models. It is instructive at this stage to evaluate the overall performance of the model, to investigate how well each model is capable of tracking the historical values of its dependent variable. In order to accomplish this, a dynamic simulation of the model was performed over the 1981-1990 period. Simulated values of the dependent variable are generated by feeding predicted values of the dependent variables into the lagged endogenous terms. Summary performance statistics for each of the endogenous variables are presented in Table 5-3.

Table 5-3: Intra-Sample Simulation Performance

Variable	Definition	Root mean square percent error
		(percent)
COW	Milk cow inventory	0.7
MPC	Milk production per cow	0.1
PROD	Total milk production	1.6
CDIS	Commercial disappearances	2.5
RFMP	Real farm milk price	5.0

Source: Estimated

Root mean square percentage errors (RMSPE) of less than 5 percent were observed for all five variables under consideration, which shows that all the model is performing well. The model appears to be weakest, however, in reproducing the real farm price of milk. However, to the extent that errors for this variable in recent periods were substantially less than errors over the entire sample size, the structure of the present model was kept for out of sample forecast.

5.4: Forecasting

Once the models were validated, the estimated coefficients were used to generate conditional forecasts of the endogenous variables over the period 1991-1995. Conditional forecasts were produced based on conditional values of the exogenous variables over the forecast period. The structure of the present model meant that assumed values of only a small number of variables were needed. Futures prices of soybean meal from the Chicago Board of Trade was used as a guidance for assumed values of beanmeal prices to 1995. The real support prices were based on support price of US$ 10.10/cwt. contained in the 1990 Farm Bill. The real US disposable income for the period 1991-1995 was derived by extrapolating current income trends. In all cases, an assumed level of inflation of 5 percent annually was assumed. The forecast values of the endogenous variables are summarised in Table 5-4.

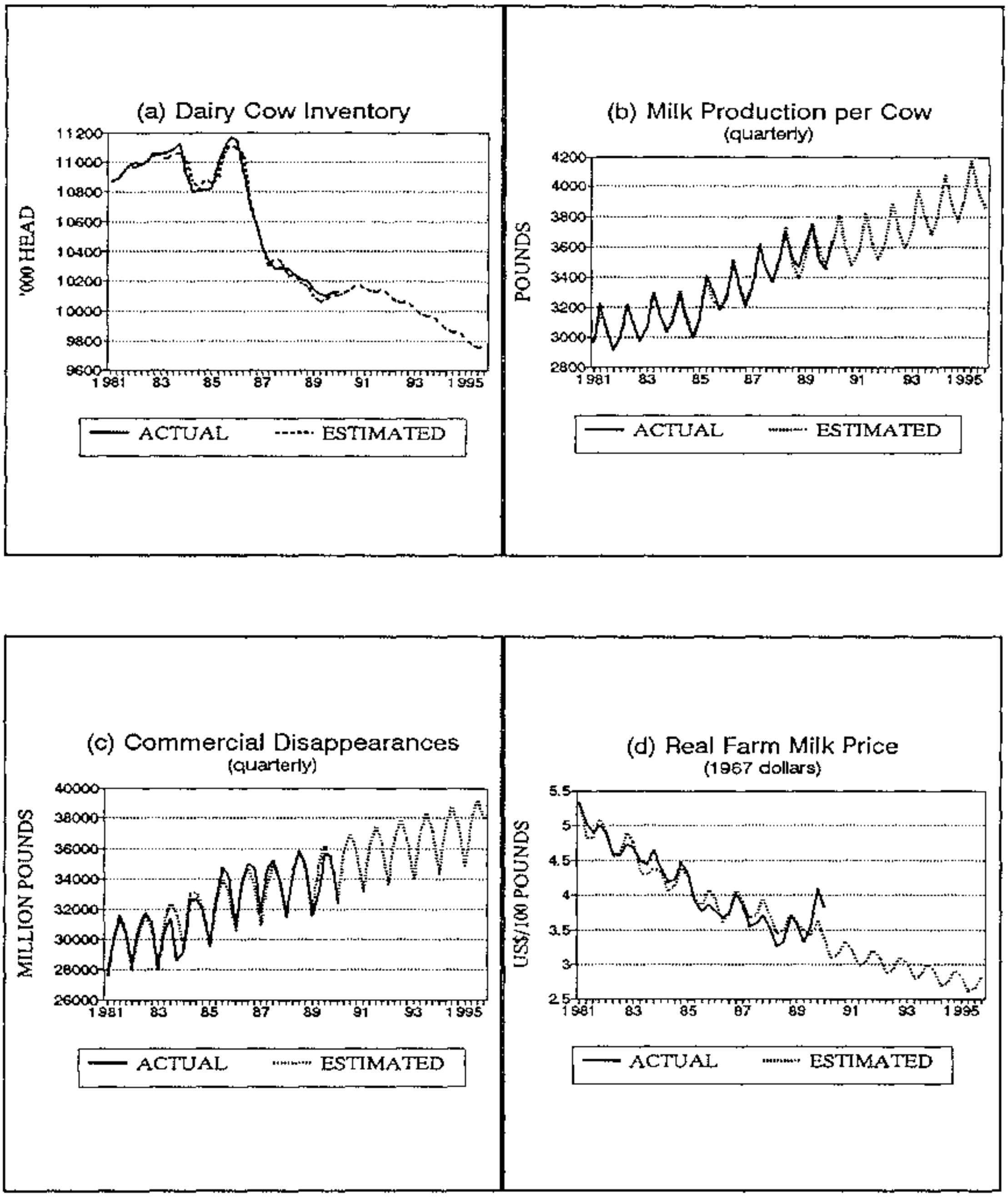
Table 5-4: Predicted Values of Selected Variables (without BST)

	COW (000 head)	MPC (lb/year)	PROD (mil.lb/yr)	CDIS (mil.lb/yr)	RFMP ($/cwt.)
1991	10,143	14,549	147,568	143,252	3.11
1992	10,077	14,815	149,286	144,955	3.01
1993	9,986	15,158	151,359	146,628	2.91
1994	9,884	15,536	153,550	148,293	2.82
1995	9,776	15,935	155,784	149,966	2.73

Source: Estimated

Figure 5-1 (a-d) shows the plots of actual and simulated values of the endogenous variables over the historical period as well as over the forecast period. The graphs show that the model estimated the actual values of all these endogenous variables very closely. The graphs also show that, for the most part, the forecasts continue trends that have been evident throughout the past decade.

Figure 5-1:Actual and Simulated Values of Selected Endogenous Variables



The results indicate that the number of dairy cows will continue to decline over the 1991-1995 period. Although consistent with other studies, the magnitude of the decline in this analysis is less dramatic than those reported in Kaiser, for instance. The number of cows is predicted to decline to 9.8 million head by the end of 1995.

Milk production per cow is expected to continue its steady upward trend over the 1991-1995 period. By 1995, average annual milk production per cow is estimated to be 15,935 pounds. This translates into an annual rate of increase of about 2.4 percent which is consistent with historical increases in milk production. This estimate compares favourably with that from Kaiser (1990).

The product of cow numbers and milk produced per cow gives the total milk production in the US. Again, the estimated total milk production over the 1991-1995 period is consistent with the general trend in milk production over the last decade. By 1995, the US will be producing an estimated 155.8 billion pounds of milk annually.

The US commercial disappearance of milk shows a slightly faster rate of growth over the 1991-1995 period. This is partly due to lower real prices of milk over this period since the support price is fixed at US$ 10.10. However, when taking the impacts of inflation into account, the real prices of milk over this period actually declines. By 1995 the real farm milk price is estimated to be $ 2.73/cwt (in 1967 dollars), a drop of about 12% from 1991 price level. This is consistent with the historical trend as real farm prices have dropped by about 4% annually during the 1980's.

5.5: Summary

This chapter has shown the dairy simulation model and why this particular model was chosen. The chapter has also summarised the results that were obtained from the model. The model used contains four behaviourial equations which explain cow inventory levels, milk production per cow, commercial disappearances (demand) for milk, and the real farmgate milk price. An identity of the product of the number of cows and the milk production per cow was used to find total milk production. All of the models were found to be satisfactory.

The models were then used to forecast through 1995. These forecasts saw several trends continuing into the future. Cow numbers were projected to continue to decline at a steady rate, while milk production per cow would steadily increase. The result was a marginal increase in total milk production. Total commercial disappearances also increased slowly but steadily. The real farm milk price was projected to continue to decline as it has done almost every year during the 1980's.

Chapter 6

Incorporating BST Into the Model

6.1: Introduction

The previous chapter explained this study's model of the US dairy industry, and projected forecasts based on that model. This chapter incorporates the use of bST into the model's forecasts for 1991 through 1995.

As was mentioned in a previous chapter, some important factors that will determine bST's effects remain uncertain at this time. These factors include the response rate (the percentage increase in milk produced per cow as a result of using bST), and the adoption rate (the cumulative percentage rate at which farmers adopt bST). Because of this uncertainty, this chapter will present several possible alternatives to account for the effects of bST use. These alternatives include three possible response rates (10%, 15%, and 20% increases in milk production per cow) and two scenarios of possible adoption rates.

The latter part of the chapter explains how the use of bST may make the US a large exporter of dairy products, and it shows the possible magnitude of the exports from the US as estimated by the model.

6.2: Impacts of BST on Production

The impacts of bST on US milk production can be derived in a straightforward fashion as follows. Two factors determine the extent by which total milk production will increase in the US following the adoption of bST. These are:

(1) the response of milk production per cow to bST and

(2) the rate of adoption of bST by farmers.

As mentioned earlier, proper management and nutrition also impact on results from bST use. This study assumes that those farmers who adopt bST are aware of these other factors and as such derive the maximum benefits from bST.

6.2a The Response Rate

Based on recent studies on the production response to bST, this study assumes that increases in the production of milk per cow (response rate) will range from 10 to 20 percent with an average of 15 percent over the period of the cow's lactation that bST is used.

BST will probably only be used, however, after the first 90 days of the cow's lactation period because earlier use may hinder the cow's ability to re-breed. Since the first 90 days of lactation account for about half of the cow's total production, bST will only raise a cow's total production by about half of the response rate. In other words, a 10% response rate will raise the cow's production 10% over the time that bST is used, but since it is given during the period of time when the cow gives half of her total production, a 10% response rate will increase total annual production by only 5%. Similarly, a 15% response rate will raise total production by about 7.5%, and a 20% response rate will result in a 10% annual milk increase. Thus, throughout this chapter, a 5% increase in total annual production was calculated for the 10% response rate, and similarly for the other two response rates.

6.2b The Adoption Rate

As previous chapters of this study have indicated, one of the most uncertain factors concerning bST is the number of farmers who will adopt it when it becomes available for use. Most previous studies have assumed that the rate of adoption will be rather slow and gradual, as is often the case with a new technology. These studies cite surveys which suggest that a few farmers will adopt bST immediately after it is made available, and increasingly larger numbers will adopt it over the ensuing years.

Yet, even if most studies agree that adoption of bST will be gradual, most have disagreed on the exact rates at which it will be adopted. This is evident in the literature reviewed in this study.

Therefore, this study will present two scenarios of possible adoption rates for the years 1991-1995. Scenario 1 is based upon the study by Fallert et al (1987), in which adoption rates were determined through a survey of US dairy farmers. Scenario 2 is based upon the paper by Tauer and Kaiser (1991), in which adoption rates were determined endogenously in the study's model based on the estimated profitability of bST use. The adoption rates for these scenarios are shown in Table 6-1.

Table 6-1: Summary of Adoption Rates Assumed by the Scenarios

Scenario	Source	Cumulative Adoption Rate (Percent of Farmers Using bST)				
		1991	1992	1993	1994	1995
1	Fallert, et al	0	10%	20%	36%	44%
2	Tauer & Kaiser	0	5%	10%	25%	40%

As the table shows, it is assumed that bST will not be used in 1991, since it is not yet available at this time. Should it become available in 1992, 10% of the dairy farmers in the US would adopt it according to Scenario 1, which is based on the nationwide survey used by Fallert, et al (1987). By 1995, according to that scenario, 44% of US dairy farmers would be using bST. The corresponding adoption rates in Scenario 2 are more conservative, with only 5% of the farmers adopting bST in the first year it is introduced. This rises steadily to a total of 40% four years after introduction.

Although the adoption rate is given here, as it is in other studies, as the percentage of dairy farmers who adopt bST, this is slightly misleading. More accurately, the adoption rate indicates the percentage of the nation's cows on which bST is used. The difference is, of course, that the 10% of the cows on which bST is used, for example, may be on only 5% or so of the nation's dairy farms. This example may actually be a realistic possibility since larger than average farms would likely be more able to adapt to the special challenges presented by bST and adopt it more quickly than smaller farms.

For the purposes of this study, however, the terminology of the "percentage of farmers" is used, to maintain consistency with previous studies. Those studies assumed that farms of all sizes were equally as likely to adopt bST, and thus there would be no difference between the percentage of farmers who adopted bST and the number of cows on which bST is used.

6.2c: Calculating the Total effect of BST on Production

Based on the above assumptions, the impacts of BST on milk production can be calculated as follows:

Change in Milk Production =(response rate/2)(milk per cow) * (adoption rate)(no. of cows)

For example, if one assumes a response rate of 10%, average annual milk production per cow of 15,000 pounds, a cumulative adoption percentage of 20%, and a national dairy cow herd of 10 million head, the increase in the amount of milk produced in the US for the year as a result of bST use is calculated as:

Change in Milk Production =(.10/2)(15000) * (.20)(10,000,000) = 1.5 billion pounds

In this example, total production without bST would have been 150 billion pounds (15,000 pounds per cow * 10 million cows), so bST use increases milk production by 1%.

6.3 Incorporating the Impacts of BST Into the Model

Using the forecasts of dairy cow inventory numbers and milk production per cow from the model in the previous chapter, and the assumed response rates and adoption rates explained above, the impact of bST use in the US for 1991-95 were calculated. The results are shown below, in pounds and in percentage of total production.

6.3a: Percentage Increases in Total Production: Scenarios 1 & 2

The increase in production as a result of bST in terms of a percentage of total national annual production can be calculated by multiplying the cumulative adoption rate by half the response rate. The results for Scenarios 1 and 2, which use different adoption rates, are given in Table 6-2 and 6-3 respectively.

Table 6-2: Percentage Increases in Total Milk Production as a Result of Using BST : **Scenario 1**

Response Rate	Cumulative Adoption Rate				
	0%	10%	20%	36%	44%
	1991	1992	1993	1994	1995
10%	0.0%	0.5%	1.0%	1.8%	2.2%
15%	0.0%	0.8%	1.5%	2.7%	3.3%
20%	0.0%	1.0%	2.0%	3.6%	4.4%

Table 6-3: Percentage Increases in Total Milk Production as a Result of Using BST : **Scenario 2**

Response Rate	Cumulative Adoption Rate				
	0%	5%	10%	25%	40%
	1991	1992	1993	1994	1995
10%	0.0%	0.3%	0.5%	1.3%	2.0%
15%	0.0%	0.4%	0.8%	1.9%	3.0%
20%	0.0%	0.5%	1.0%	2.5%	4.0%

According to Scenario 1, bST would increase total milk production the first year it is introduced by 0.5% - 1.0%, depending on the response rate. After four years, it would have raised production by as much as 4.4%. The increases presented in Scenario 2 are somewhat lower, because of the slower adoption rate. The percentage increases range from as little as .3% the first year to as much as 4% after four years.

6.3b: Increases in Total Milk Production Resulting from BST Use: Scenarios 1 & 2

The previous chapter explained how forecasts for cow inventory, milk production per cow, and total milk production for 1991-1995 were obtained from the Quarterly Dairy Model. Those forecasts will now be used, along with the assumed response rates and adoption rates developed in this chapter, to estimate the increase in milk production that would result from the introduction of bST. These estimates of production increases were found by substituting the forecasts for cow inventory and milk production per cow from the model, along with the various response rates and adoption rates, into the equation shown previously in this chapter for the change in milk production. The results for Scenarios 1 and 2 are shown in Tables 6-4 and 6-5, respectively. The results are also displayed graphically in Figures 6-1 and 6-2.

Table 6-4: Total Milk Production (Billions of Pounds): **Scenario 1**

Response Rate	1991	1992	1993	1994	1995
0% (no bST)	147.6	149.3	151.4	153.6	155.8
10%	147.6	150.0	152.9	156.3	159.2
15%	147.6	150.4	153.6	157.7	160.9
20%	147.6	150.8	154.4	159.1	162.6

Source: Estimated

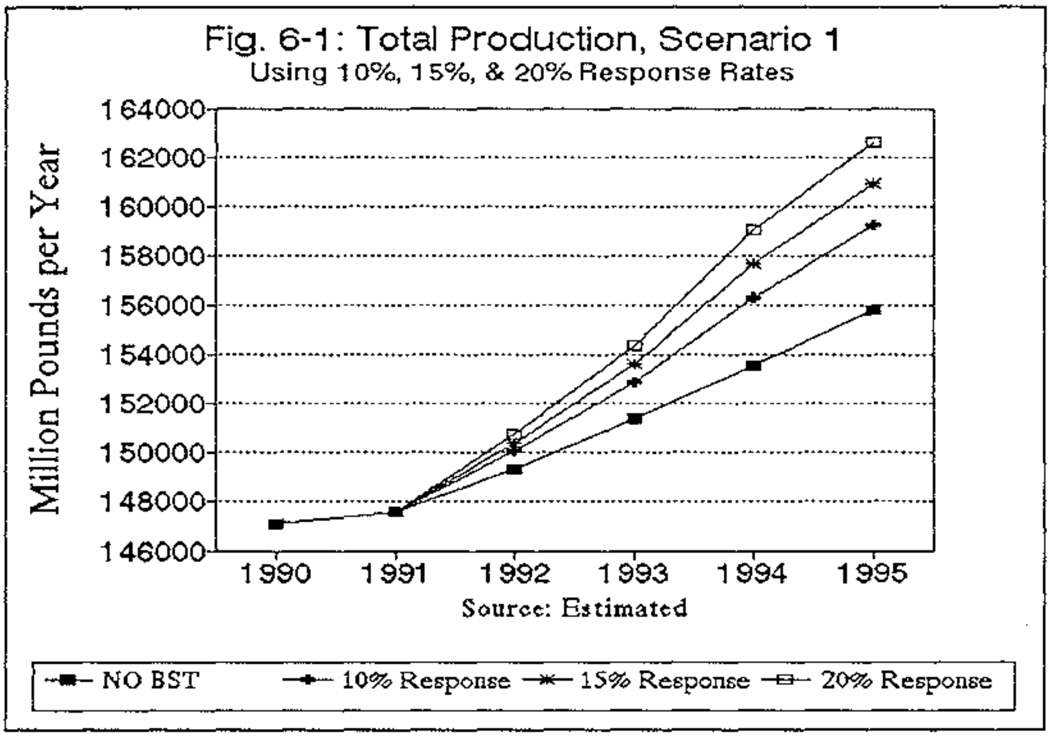
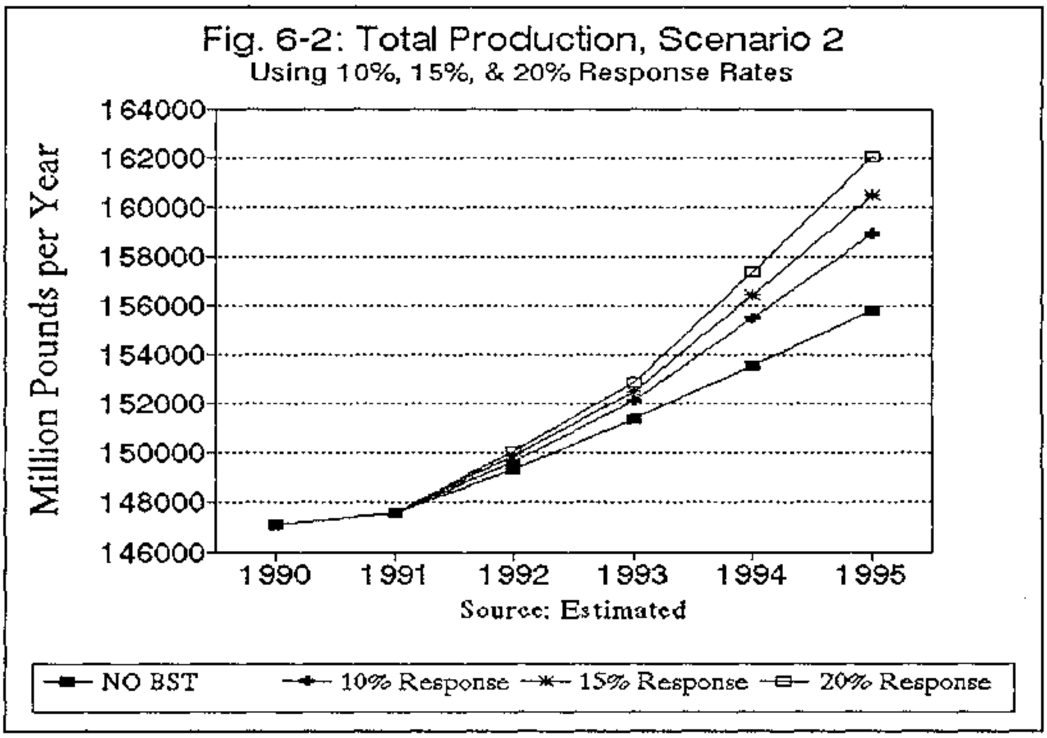


Table 6-5: Total Milk Production (Billions of Pounds): **Scenario 2**

Response Rate	1991	1992	1993	1994	1995
0% (no bST)	147.6	149.3	151.4	153.6	155.8
10%	147.6	149.7	152.1	155.5	158.9
15%	147.6	149.8	152.5	156.4	160.5
20%	147.6	150.0	152.9	157.4	162.0

Source: Estimated



The first row of Table 6-3 and Table 6-4 show total annual milk production in the US from 1991-1995 as estimated by the Quarterly Dairy Model. According to the forecasts, production will rise steadily, by about 2 billion pounds of milk per year.

The second row of Table 6-4 shows production if bST is introduced beginning in 1992, has a 10% response rate, and is adopted at the rate described for Scenario 1. As the table shows, initially there is only a modest increase in production of 0.7 billion pounds, because only 10% of the nation's farmers have begun using bST. As bST is more widely adopted over time, however, the increase in milk production becomes more substantial. By 1995, the same 10% response rate would lead to an increase in production of 3.4 billion pounds compared to the baseline situation in which bST was not available. This assumes that 44% of US dairy farmers will adopt bST by that time.

If the response rate is as great as 20%, the effects of bST would be even more substantial. For example, a 20% response rate along with a 44% cumulative adoption rate in 1995 would result in 162.6 billion pounds of milk production. This would be an increase of 6.8 billion pounds over the production total without bST.

Figure 6-1 displays the same information in graphic form. The graph contains one line which represents the baseline situation of no bST, as well as a line for each of the 10%, 15%, and 20% response rates. As the graph shows, the increase in production in 1992 for all three of the response rates is only slightly higher than the baseline with no bST, because few farmers will have adopted bST in the first year it is available. By 1995, however, the differences become dramatic, showing the ability of bST to substantially increase the US milk supply.

Table 6-5 and Figure 6-2 can be interpreted in the same manner as those above. Because Scenario 2 assumes a slower rate of adoption, however, the increases in milk production caused by bST are significantly lower than they were in Scenario 1, particularly in the first two years after bST is introduced. Even in this scenario, though, bST does raise total production greatly by 1995. The increase may be as much as 6.2 billion pounds by that time. Even more significantly, the increase in milk production from 1990 to 1995 in both scenarios is quite substantial. The estimated yearly increase of about 2 billion pounds, coupled with increases from the use of bST, could raise production from its 1990 level of 147 billion pounds to over 162 billion pounds by 1995. This is an increase of over 15 billion pounds, or about 10%, over 1990 production levels.

6.4: The Effects of BST on Excess Supply

The previous section showed that the adoption of bST could increase the supply of milk in the US significantly over the next five years. If the demand for milk does not keep pace with the increasing supplies, excess supplies (surpluses) of dairy products will develop. Those excess supplies would then need to be placed in storage or exported to prevent them from disrupting the price support system. This section will estimate the possible magnitudes of excess supplies of dairy products that may develop if bST is adopted in the US.

6.4a: Support Prices and Excess Supply

Chapter 4 discussed the theoretical effects that the adoption of a new technology, such as bST, would have if it were introduced into a market in which a producer support price were present. The technology would reduce production costs and thus increase supplies, shifting the supply curve to the right. In a perfectly competitive market this shift would lead to lower prices for the producer, bringing the market back into equilibrium. If, however, a support price is present, as is the case in the US dairy industry, the price is not allowed to fall to the market clearing price. Thus, the quantity supplied exceeds the quantity demanded, and a surplus is created.

When a surplus develops the government must intervene to remove it, in order to maintain the support price. Import barriers may also need to be established to prevent cheaper foreign products from undercutting the domestic support price. Chapter 2 explained the methods by which the Commodity Credit Corporation (CCC) removes dairy surpluses from the market, and the quotas which the US imposes on dairy imports.

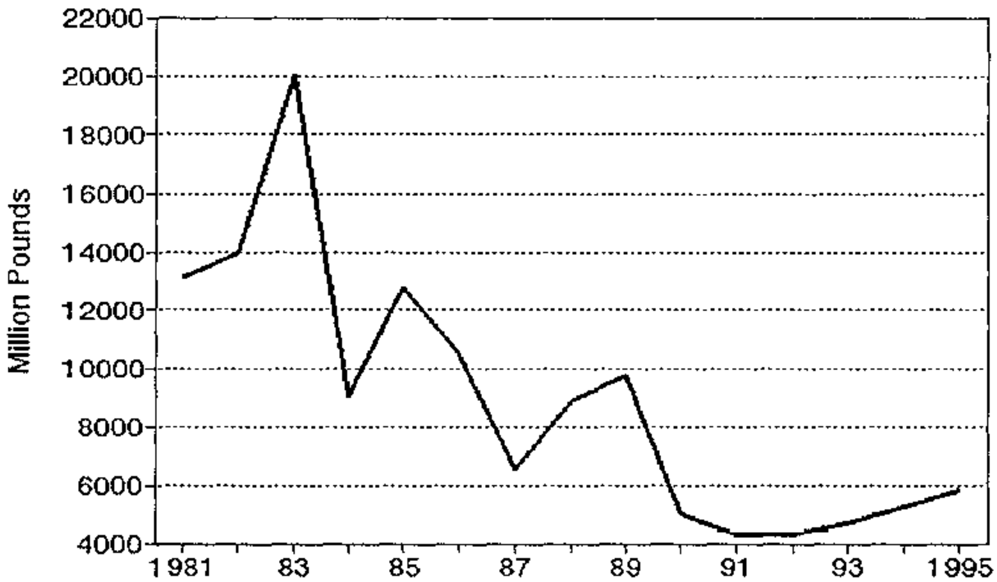
6.4b: Measuring Excess Supply

Excess supply is simply the difference between the quantity supplied and the quantity demanded. If the quantity supplied is greater than the quantity demanded, then the difference between them is the amount of the excess supply, or surplus. Therefore, to estimate the excess supply, it is necessary to estimate both the quantity demanded and the quantity supplied.

Equations for both supply and demand are found in the Quarterly Dairy Model in Chapter 5. Supply is estimated by the equation for total milk production, which is simply the number of dairy cows in the US multiplied by the milk production per cow. The demand for milk is found by estimating an equation for the commercial disappearances of milk. Commercial disappearance is the difference between total production during the quarter and the change in inventory stocks at the end of the quarter. It thus measures the amount of milk that was consumed during the quarter. Commercial disappearances are estimated by Equation 4 of the model.

As Chapter 5 explained, once equations for the model were found, those equations were used to forecast for the period 1991-1995. Figure 6-3 shows the excess supplies for the period 1981-1995, including the forecasts the model for 1991-1995.

Figure 6-3: Dairy Excess Supply
Annual Totals



Source: 1981-90:USDA 1991-95:Estimated

As Figure 6-3 shows, excess supplies of dairy products peaked in the early 1980's and have since declined to relatively low levels. Reasons for the decline in excess supply including a declining support price, the DTP, international market conditions, and other factors were discussed in previous chapters. The graph also shows that the model's forecasts are relatively small compared to the surpluses of the early 1980's. The forecasts also predict that excess supplies will rise, but only slightly, between 1991 and 1995. Since the CCC estimates that approximately 5 billion pounds of surplus dairy products can be disposed of without creating a market disturbance, the forecasts suggest that, without the introduction of bST, excess supplies should not create a major problem during the first half of the 1990's.

6.4c: Estimating The Effect of BST on Excess Supplies

Previously in this chapter, it was shown how bST would increase milk production. A similar method can be employed to measure the effect bST would have on increasing the excess supply of milk. This is done simply by subtracting the forecast values for commercial disappearances from the forecast of total production if bST is adopted. Again, the three possible response rates and two scenarios of adoption rates were used to estimate the effects of bST on production.

Figures 6-4 and 6-5 show the forecasts for excess supply under Scenario 1 and Scenario 2, respectively. In the graphs, 10%, 15%, and 20% response rates are compared to the baseline of no bST.

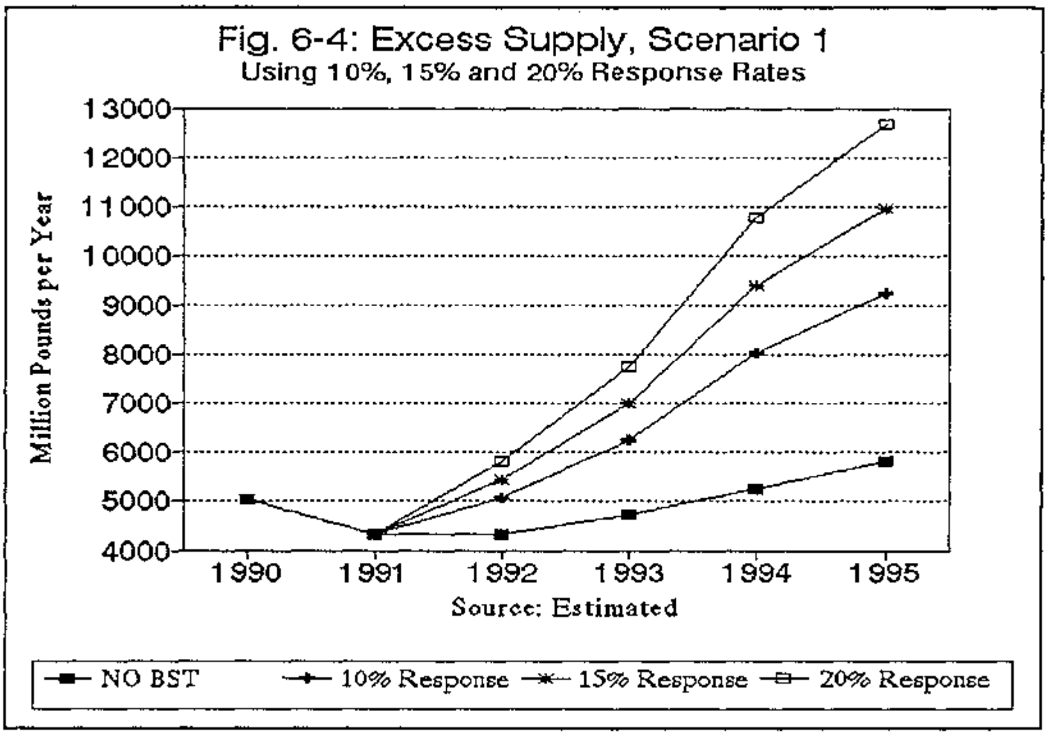


Fig. 6-4: Excess Supply, Scenario 1
Using 10%, 15% and 20% Response Rates
Million Pounds per Year
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
1990
1991
1992
1993
1994
1995
Source: Estimated
NO BST
10% Response
15% Response
20% Response

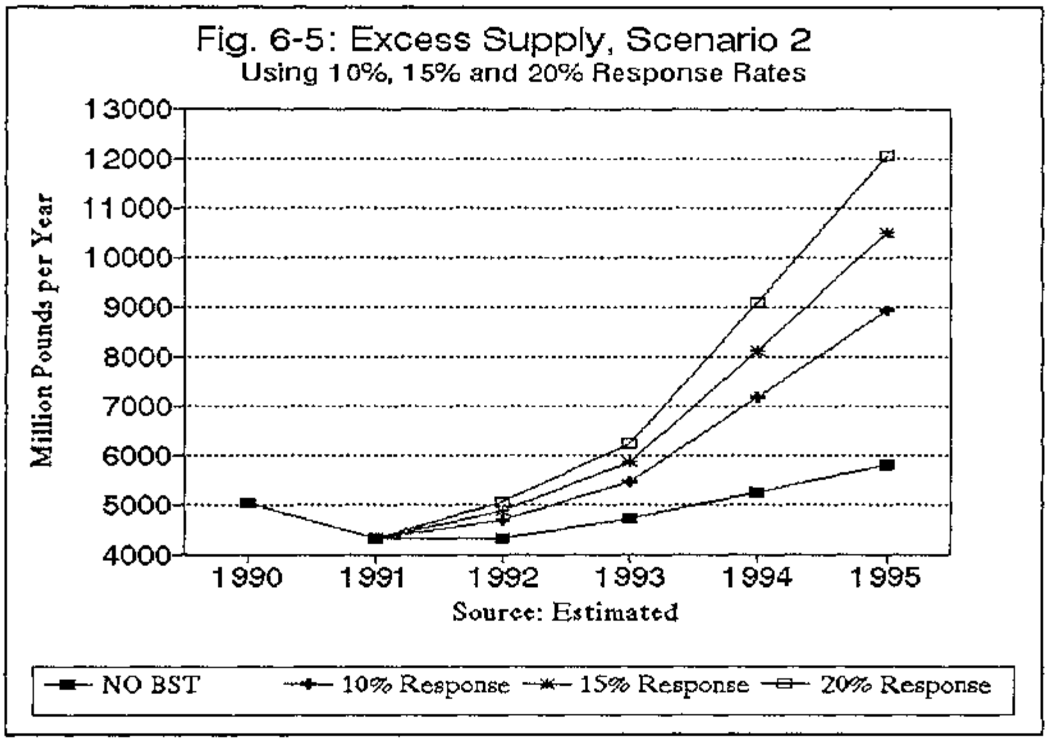


Fig. 6-5: Excess Supply, Scenario 2
Using 10%, 15% and 20% Response Rates
Million Pounds per Year
13000
12000
11000
10000
9000
8000
7000
6000
5000
4000
1990
1991
1992
1993
1994
1995
Source: Estimated
NO BST
10% Response
15% Response
20% Response

As the graphs show, without bST the excess supply of dairy products would be a relatively modest 4 billion to 6 billion pounds per year every year through 1995. If, however, bST is adopted by farmers at the rate predicted by Scenario 1, the excess supply of dairy products could rise to over 11 billion pounds or more by 1995, depending on the response rate. In Scenario 2, the excess supplies grow more slowly, but still may exceed 10 billion pounds by 1995. Thus, even conservative estimates of the effects of bST would still create excess supplies which would rival the largest surpluses of the early 1980's.

6.5 Effects of the 1990 Farm Bill

The above analysis has included several implicit assumptions that are based on the 1990 Farm Bill. For example, this study has made forecasts through 1995, because the 1990 Farm Bill has established policy until then. Thus, one can be relatively certain that most of the policies in place will remain unchanged through 1995. Predictions for further years, however, would be based on a much greater degree of uncertainty, because they would almost certainly have to assume that the policies of the 1990 Farm Bill would be carried forward in future agricultural legislation. As the differences between the 1980, 1985, and 1990 Farm Bills show, policies have changed greatly over time, and predictions beyond the current Farm Bill would be unreliable.

The difference between Farm Bills is, in fact, one of the distinguishing features between this study and previous studies of the effects of bST. Other recent studies, which were reviewed in this study, based their predictions on the assumption that the policies of the 1985 Farm Bill, including a declining Support Price, would be continued in the 1990 Farm Bill. As this study has mentioned, that policy and others were altered.

6.5a The Effect of the Support Price

This study, in its analysis of the effects that bST would have on milk production, assumed that the price of milk, both at the farm level and retail level, would remain relatively unaffected by the adoption of bST. Although one would usually assume that an increase in supply would lead to declining prices both at the farm and retail levels, the support price prevents this effect by keeping the price from falling below the supported level.

Equation 5 in the Quarterly Dairy Model (see Table 5-1) showed that the real farm milk price is a function primarily of the real effective Support Price, which is the Support Price less any mandatory deductions (such as those deductions which paid part of the cost of the DTP). Therefore, if the Support Price remains constant at $10.10/cwt. as the 1990 Farm Bill authorises, then the real farm milk price will remain relatively unchanged (relatively unchanged, but not entirely, because the real farm milk price is also dependent, to a lesser extent, upon cow inventory numbers and the seasonal dummy variables).

This is an important distinction because if the Support Price were allowed to fall if production rose above a certain point, as was the case in the 1985 Farm Bill, then the study would naturally assume that producers would base their production decisions on the declining Support Price. This is the assumption that has been made by previous studies. If, however, the Support Price is going to remain constant for the next five years, and the real farm milk price is dependent to a large degree on the Support Price, one can be relatively certain that the farm price will not fall below a certain level even if the supply is increased by the adoption of bST. Since the real farm milk price forecast in Chapter 5 is only slightly higher than the Support Price, one can be relatively confident that the introduction of bST will have a rather small effect, if any, on farm prices. Therefore, this study assumed that the forecasts for the real farm milk price would not be altered by the introduction of bST, and the increases in production from the adoption of bST were added onto the forecasts to find the total production after bST is introduced.

Similarly, this study found that the demand (commercial disappearance) of milk is a function of the real farm milk price, real disposable income, and seasonal dummy variables. Since the study assumes no change in the real farm milk price if bST is introduced, and there is no reason to alter the other independent variables, the introduction of bST will not affect the quantity of milk demanded. Therefore, the forecast value for excess supply for 1991-1995 would be the difference between the forecast of total production including bST and the original forecast of commercial disappearances.

6.5b: The Effect of Price Deductions

As the previous section mentioned, the Support Price will remain constant through 1995. As Chapter 2 discussed, however, the 1990 Farm Bill established a policy that any producer who exceeds a certain production level (based on that producer's output over the past 5 years) will incur a mandatory deduction from the price he is paid for his milk. Since the price deduction affects only those farmers who increase production, it will make the use of bST unattractive to many producers. Other producers, however, would find that the benefits of using bST to increase production would outweigh the costs of the price deduction, and would therefore choose to use bST. Still others would find that they could increase their profitability by adopting bST and simultaneously reducing their herd size. They would thus take advantage of the cost savings from bST without increasing their total production enough to incur the price deduction.

The price deductions would therefore probably affect the number of producers who would adopt bST, reducing the adoption rate. As was mentioned previously in this chapter, the adoption rate is one of the uncertainties concerning the introduction of bST. Several previous studies have used very disparate adoption rates. It is therefore even more difficult to predict what the adoption rate would be now that those who adopt bST would face a possible price deduction.

Because of that uncertainty, this study has used two relatively conservative adoption rates for the two scenarios. Scenario 2 is the more conservative of the two, and may therefore be regarded as more likely to be accurate. It is impossible at this time, however, to be certain what the adoption rate will be, so both are presented as possibilities.

6.6: Effects on Other Dairy Exporting Nations

The above analysis has shown clearly that the adoption of bST in the US could potentially produce substantial surpluses of milk in the US, perhaps in excess of 12 billion pounds. Assuming that 5 billion pounds could be disposed of through domestic programs, 5 billion to 7 billion pounds of dairy products would still need to be disposed of. Much of the excess supply of dairy products would undoubtedly end up on the international market.

To put these estimated increases into perspective, New Zealand's total milk production in 1988 amounted to approximately 17 billion pounds, of which about 13 billion pounds was exported (NZ MERT). Thus, the increase in US excess supplies to as much as 12 billion pounds, although small when compared to the total US production of 145 billion pounds, means that the use of bST in the US could create a surplus in the US which would rival New Zealand's total annual exports. If a large percentage of the US surplus ends up on the world market, as it has in the past, the US could potentially become almost as large an exporter of dairy products as New Zealand by 1995.

6.6a: The Effect of Subsidised Exports

Because the US cannot produce dairy products as cheaply as other dairy exporters, particularly New Zealand, the US would most likely have to use some form of export subsidisation to dispose of its surplus dairy products on the world market. Chapter 2 discussed some of the subsidy programs, as well as foreign aid donation programs the US has employed in the past to dispose of dairy surpluses. As Chapter 4 showed, the use of export subsidies by a large exporter (which the US would be if the surpluses calculated in this chapter are exported) would drive the world price down. Because the US has not been a major player in the international dairy market in the past, the emergence of the US as a dairy exporter, which may follow the adoption of bST in the US, could create quite a shock to the market.

The exports from the US, in addition to lowering the world price, would also tend to displace some of the markets of the current dairy exporting nations. Since New Zealand has adopted a policy not to use export subsidies, it could be potentially hardest hit if the New Zealand dairy product prices were underpriced by US export subsidies. Since the US exports mainly dry milk powder and butter, New Zealand could be particularly hard hit, since those are also New Zealand's principle exports. Australia, another large exporter of dry milk powder, could also be adversely affected if the US emerges as a larger exporter.

The EC, which is the largest dairy exporter, does have an aggressive export subsidisation policy. It would likely lose less market share to emerging American competition, but the result could become quite costly to the EC if it is forced to increase export subsidies to compete against the US.

6.6b: Effects on the World Price

This analysis has assumed that if bST causes large surpluses in the US, the US would have to use export subsidies to sell their surplus dairy products on the world market. If this occurs, the world price may become as depressed as it was in the early 1980's, when substantial surpluses forced several exporters to subsidise their exports of dairy products. Export subsidisation by the US could also lead to a bidding war between the US and the EC, which would not only be costly to those nations, but also to non-subsidising nations such as New Zealand which would see the world price drop and its revenues decline.

The magnitude of any price effect on the world dairy market is difficult to gauge accurately because of he complex structure of he industries and the great amount of government intervention in he industry.

6.7: Other Issues and Potential Developments

The above analysis has assumed that the US is the only country that will use bST over the 1991-1995 period. However, should the US adopt bST, the EC could also do the same to maintain their competitiveness on the world dairy market. Such a situation would further add to the world surplus of dairy production. As a response to these surpluses, world prices of dairy products could decline significantly.

An important implication of this development would be the threat that the US would represent to other dairy exporters. As a result, there might be increasing pressures on these exporters, in particular the EC countries, to also adopt the use of bST in order to maintain and increase their competitiveness on the world market. Since the EC is by far the largest producer and exporter of dairy products in the western world, the adoption of bST could compound the surpluses of dairy products on the world market.

As discussed above, such a situation could potentially lead the major exporters, the EC and the US, to use export subsidies in order to dispose of their surpluses. Previous experiences with the use of export subsidies during the mid 1980's have shown clearly that such a practice would not benefit the major producers and exporters of dairy products.

In New Zealand, the adoption of bST would not necessarily lead to similar gains in production as in the US. This is mainly due to the forage based dairy production system in New Zealand which is not fully compatible with the use of bST, as was discussed in a previous chapter. In order to capture the full benefits of bST, major changes in management and production practices would be required. Thus New Zealand's international competitiveness in dairy could be seriously affected by adoption of bST in other countries. New Zealand could see its market share eroded if its customers turn to cheaper, subsidised products from the EC and the US. The potential drop in the world price due to the added supplies from the US on the market and from the increased use of export subsidies, would also hurt New Zealand revenues. Furthermore, because bST is a cost-reducing technology, if it is adopted in other dairy producing countries, but not in New Zealand, then New Zealand's comparative advantage as the world's lowest cost dairy producer would be eroded.

6.8: Summary

This chapter has shown how the use of bST is incorporated into the US dairy simulation model. It has shown the assumptions that have been made regarding bST use, and has shown three possible scenarios of possible response rates in milk production. The results show that bST could increase US total milk production by nearly 7 billion pounds per year by 1995. This increase in production would add to an already growing surplus, which could result in a total excess supply of 12 billion pounds by 1995. This surplus would rival the record surpluses of the 1980's.

These results indicate that, if the US adopts bST as the model has forecast, then the US will have very significant supplies of surplus dairy products which it will need to dispose of by 1995. Much of this surplus will undoubtedly be given away or sold on the international market at subsidised prices.

The implications to the current dairy exporters are rather clear. Added supplies from the US onto the international market will increase competition and lead to reduced prices, especially for butter and skim milk powder. This could take away some of New Zealand's market share, and would likely force the EC to increase its own export subsidies. In the end, the adoption of bST in the US could be quite costly to the current dairy exporters, if the US enters into a larger role as a dairy exporter.

Chapter 7

Summary, Conclusions, and Suggestions for Further Research

7.1: Summary of the Study

The objective of this study was to estimate the effects that the adoption of synthetic bovine Somatotropin (bST) by US dairy farmers would have on the US dairy industry, and what the implications of bST use in the US would be for international trade of dairy products.

BST is a growth hormone for cattle that increases milk production. Recent advancements in biotechnology have led to the development of a synthetic form of bST. Although bST has not yet been approved for use in the US, it is expected to be approved soon, and could have a great economic impact on the dairy industry.

The primary focus of the study was the specification and estimation of an econometric model of the US dairy industry. Once simulated and validated, that model was used to generate forecasts of the production, consumption, and price of dairy products in the US for the period 1991-1995. Based on those forecasts, several scenarios of the use of bST were developed to analyse its empirical effects on the US dairy industry. Among these effects, the excess supplies from the US that would be created by the widespread adoption of bST were calculated. Finally, the study discussed the resulting impacts that the excess supplies of dairy products from the US would have if they were traded on the world market.

Before the actual development of the econometric model, however, the study discussed several relevant topics, including the US dairy industry and policy. The study noted that the US dairy industry is one of the largest in the world, but has traditionally been only a minor participant in world dairy trade. The current US dairy policy environment is shaped by the 1990 Farm Bill, which includes a provision to maintain the current minimum dairy support price. This is an important distinction from the 1985 Farm Bill, and one which previous studies of bST had not accounted for.

This study also discussed the current world dairy trade environment. The dairy products industry is one of the most heavily subsidised and rigidly protected industries in the world. As a result, world dairy trade accounts for only a small percentage of world dairy production. Because of its small size, the international market is subject to volatile price swings.

While the EC and New Zealand are the primary dairy exporters, the study also investigated the possibility of the US becoming a large dairy exporter. This subject was discussed in a paper by Blayney and Fallert (1989), who concluded that the US could become a larger dairy exporter in the 1990's. The role of the US as a dairy exporter would be enhanced, they said, if the EC maintains dairy production quotas; US policies, such as export enhancement programs, that encourage dairy exports are adopted; and if US farmers adopt bST.

The study also discussed the impacts of bST and the controversy that surrounds it. Although bST is a cost-reducing technology, many farm groups in the US are opposed to its use. They believe that it will fundamentally restructure the US dairy industry, and reduce farm income. Some consumer groups are also opposed to bST because they fear that it may be unsafe, although no studies have found conclusive evidence of adverse effects on either cattle or human health. Other dairy producing countries, such as the EC, have banned bST, citing concerns by consumer groups for human health.

Several previous studies which examined the economic impact of bST on the US dairy industry were reviewed. These studies generally agreed that bST would not have as great an effect as previous studies had indicated. They did agree, however, that bST would tend to continue certain trends in the dairy industry including declining cow numbers, declining farm numbers, and increased milk production per cow. Many of the assumptions these studies used, including the response rate, adoption rate, and others remain controversial. This study discussed these and other issues.

Before developing an econometric model of the US dairy industry, the study investigated the theoretical and conceptual implications of the adoption of bST in the US. It discussed the effects of the adoption of a new technology, such as bST, in an industry which is supported by a producer support price. It was found that such a situation led to an excess supply, or surplus, which the government would have to remove in order to maintain the support price. One means of removal is to export the products, often at subsidised prices. If a country does export a relatively large amount of a good at a subsidised price, the international price will decline, and revenues for other exporting countries will fall.

Chapter 5 of this study developed an econometric model of the US dairy industry. The quarterly model contains four behavioural equations which explain cow inventory numbers, milk production per cow, commercial disappearances of milk (demand), and the real farm milk price. An identity of the product of the number of cows and the milk production per cow was used to find total milk production. All of the equations performed satisfactorily. Once the equations had been validated, they were then used to simulate forecasts through 1995. Cow numbers were projected to continue to decline at a steady rate while milk production per cow would increase. The result was a marginal increase in projected total milk production. Total milk consumption was projected to increase slowly, but steadily, while the real farm milk price declined at a constant rate. These projections show, to a great extent, a continuation of trends that were evident through the 1980's.

In Chapter 6, the effects of the adoption of bST were incorporated into the model. Since bST has not yet been approved for use, it was assumed that bST would first be introduced and adopted in 1992. Projections were made through 1995 based on the forecasts from the model and from assumptions concerning the response rate and adoption rate. Three possible response rates (the percentage increase in milk production per cow that occurs as a result of bST use) of 10%, 15%, and 20% were assumed. Also two possible scenarios of adoption rates (the rate at which farmers begin using bST) were developed. The adoption rates were based on those used by Fallert, et al (1987) and Tauer and Kaiser (1991).

The predictions indicated that, depending on the response rate and adoption rate, US milk production could rise from its 1990 level of 145 billion pounds to over 165 billion pounds by 1995. Also, excess supplies of dairy products could be as high as 11 or 12 billion pounds in 1995 if bST is adopted, compared to only 5 or 6 billion pounds if it is not. These projected surpluses would be nearly as great as the record surpluses of the early 1980's.

The study then discussed the implications of these projected surpluses on the international dairy market. The US would most likely try to dispose of its surpluses on the international market, either by donating them as food aid, or selling them at subsidised prices. The emergence of the US as a dairy exporter would adversely affect current exporters, especially New Zealand.

7.2 Conclusions

There are several important conclusions that can be drawn from this study. One is that a reliable, and relatively simple, model of the US dairy industry can be developed. The quarterly model presented in this study, which consists of four behavioural equations and one identity, satisfactorily estimates supply, demand, and farm prices for the dairy industry. The model tracks past data very well, performs satisfactorily on several statistical tests, and projects forecasts that appear to be reasonable.

Another important conclusion is that, if current policies are maintained, the adoption of bST in the US will raise excess supplies, perhaps dramatically, within a few years of being introduced. This study found excess supplies that can be directly attributed to the use of bST alone at 5 billion to 7 billion pounds within four years of its introduction, using relatively conservative assumptions of the response rate and adoption rate. According to this study's forecasts, that would give the US an excess supply of 10 billion to 12 billion pounds of dairy products. This surplus is nearly as great as the record surpluses of the early 1980's, and rivals New Zealand's total annual export volume.

It can also be concluded that if such surpluses do develop in the US, and the US employs the same export policies it has in the past to dispose of the surplus, the effect will be damaging, perhaps very damaging, to other dairy exporting countries, especially New Zealand. The US would likely subsidise its dairy exports, and even give much of it away, which would tend to reduce the world price. The subsidised exports from the US would also likely take market share away from current exporting countries by undercutting their prices.

New Zealand is especially vulnerable to the emergence of the US as a major player in the world dairy market for several reasons. Perhaps most importantly, New Zealand has adopted a policy of not subsidising exports, and so it could not compete with subsidised exports from the US without cutting its own price of dairy products. Furthermore, US dairy exports would almost certainly consist of butter and skim milk powder, which are also

New Zealand's primary dairy exports.

Subsidised exports from the US would also compete against products from the EC, which also subsidises dairy exports. The EC could avoid losing market share to the US, but would likely have to increase its own subsidies, and accept lower prices, to do so.

Finally, because of the small size of the world dairy market and its price volatility, any sudden increase in excess supply from a country such as the US would lead to a decline in prices and profits for current dairy exporters. Since New Zealand is the only country in the world that depends upon the dairy industry for a significant portion of its foreign exchange earnings, the New Zealand economy would be hurt more than any other by the emergence of the US as a large exporter of dairy products.

7.3: Suggestions for Further Research

As this study has noted, the effect of bST remains one of the most controversial subjects confronting agriculture today. There are numerous aspects of this subject that need further research, a few of which are discussed in this section.

Many recent studies, including this one, have used the adoption rate found in the study by Fallert et al (1987) as the basis of their adoption rate. However, the survey which was used to determine the adoption rate for the Fallert study was conducted five years ago, as of this writing. In those five years, many factors which affect farmers decisions about bST have changed, including the Farm Bill, the recent instability of farm prices, and a growing perception of consumers' sensitivities to chemical additives to the food supply. It would therefore be interesting to conduct another survey to determine farmers' attitudes toward bST today. It is likely that such a survey would find a significant difference between the predicted adoption rate from the late 1980's and today.

This study did not attempt to calculate the magnitude of the reductions in the world price that could occur if the US becomes a large dairy exporter, because this subject is beyond the scope of this paper. Such a study of bST's international price effects would be interesting. That study would have to take into account the effects of the current border restrictions, production and export subsidies, trade volumes, and other factors which are difficult to determine. Linked to such a study would be the probable effects that the current GATT negotiations could have if those negotiations succeed in liberalising world agricultural trade.

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