ACCOUNTING FOR FEDERAL DAIRY PROGRAM EXPENDITURES:
A MACROECONOMIC APPROACH

by

Stacey Lynn Suydam

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APPROVAL

of a thesis submitted by

Stacey Lynn Suydam

This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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ABSTRACT

Dairy products account for 13 percent of the total cash receipts from all farm commodities. In addition, fluid milk and dairy products represent about 15 percent of consumer expenditures for food. The U.S. dairy industry is subjected to more federal government regulation than any other agricultural industry and therefore, is highly affected by farm policy decisions. Although many studies have evaluated the effects of government intervention in the dairy sector, none have done so in a fully simultaneous, general equilibrium context.

The objective of this study is to specify equations which capture the interaction between the government sector and the dairy sector. The equations needed to account for the direct and indirect linkages between the U.S. dairy sector and the federal government sector were specified according to economic theory and then estimated using the ordinary least squares estimation procedure. The estimated equations were then validated by simulating outside of the sample period and examining the root-mean-square percent error. In order to simulate the dairy sector model in a general equilibrium context, the equations were endogenized into an existing macroeconometric model (COMGEM). This provides a framework which allows the analysis of the impacts of changes in various policy variables on the dairy and government sectors, as well as the general economy.

The study examines the effects of specifying the price support for milk an additional 25 cents per cwt lower than the levels established in the 1985 farm bill for 1988 and 1989. The analysis implies that additional reductions in the price support for milk are needed in order to bring the current production/consumption imbalance back into line. The small reduction in this component of the farm program did not significantly affect macroeconomic level variables, but did reduce federal expenditures on the dairy program without significantly reducing net farm income.

Alternative policy scenarios can be evaluated using this framework to assess the potential impacts of proposed policy changes on the farm sector and the cost to taxpayers of implementing the changes.
CHAPTER 1

INTRODUCTION

The dairy industry plays an important role in U.S. agriculture with approximately 13 percent of total cash receipts from all farm commodities coming from dairy products (USDA, 1984). In addition, fluid milk and dairy products represent about 15 percent of consumer expenditures for food (USDA, 1984). The U.S. dairy industry is unique in that it is subjected to more federal government regulation than any other agricultural industry and therefore is highly affected by policy decisions. Federal government payments for dairy programs have exceeded $1 billion annually since the 1979-80 marketing year and reached a record level of $2.6 billion during the 1982-83 marketing year (USDA, 1984). Although net government removals began declining in 1984 due to the dairy diversion program and a lower milk price-feed cost ratio, significant production/consumption imbalances continue to remain a problem. Increased government expenditures on farm programs, along with a large federal deficit, have prompted policy-makers to consider proposals to reduce government outlays for farm programs. These proposals have the ability to significantly impact the structure and financial performance of the U.S. dairy industry, and therefore, these potential impacts should be examined prior to enactment of legislation.
History of Dairy Programs

Given the degree of dairy market regulation, it is useful to discuss the two principal federal programs that pertain to the dairy industry.

The dairy price support program, authorized by the Agricultural Act of 1949, supports the price of milk received by farmers through government purchases of butter, nonfat dry milk, and American cheese. The Secretary of Agriculture is authorized to determine the specific support price within maximum and minimum prices specified in the legislation. Generally, the minimum support price has been set at 75 percent of parity and the maximum at 90 percent. However, the minimum support price has been temporarily raised from the 75 percent level to 80 percent by Congress four times: September 1960, August 1973, October 1977, and November 1979.

Prior to 1977, support prices were set annually at the beginning of the marketing year and were effective throughout the year. The Food and Agriculture Act of 1977 required a mid-year adjustment to reflect changes in the parity index during the first six months of each marketing year. This had the effect of raising the support price in the middle of the marketing year to keep up with increases in the index of prices paid by farmers. As a first step toward bringing supply back in line with consumption, legislation was enacted on March 31, 1981, which rescinded the scheduled mid-year increase in the support price.

In 1981, a time of large production surpluses, a set of triggers relating the minimum support price level to the size of Commodity Credit Corporation (CCC) purchases was established. As long as large purchases continued, the 1981-82
support price was set at the 1980-81 level of $13.10 per cwt, which was 72.9 percent of parity in September 1981. Only if surpluses declined to specified levels would supports be set at 70 or 75 percent of parity. This was a major departure from the traditional price support policy under which price changes were tied directly to parity.

With continued surpluses in 1982, legislation was enacted which froze support prices for two years and provided for deductions from milk producers' marketing receipts to partially offset increasing government costs.

The 1982 legislation proved to be unpopular, therefore, the 1983 Dairy and Tobacco Adjustment Act lowered the minimum support level from $13.10 per cwt to $12.60 per cwt and allowed for additional reductions on April 1 and July 1, 1985, if net government purchases were projected to be above six billion pounds or five billion pounds, milk equivalent, respectively.

The 1983 Act amended the 1949 Act to provide for a 50-cent per cwt deduction on milk marketed for product promotion, research, and nutritional education, and also initiated a voluntary 15-month paid diversion program which started on January 1, 1984. Producers who elected to participate in the diversion program and reduced their milk marketings between 5 and 30 percent below their base period production were paid $10 per cwt for these reductions. Both the diversion program and the 50-cent per cwt deduction ended on March 31, 1985.

Support prices in the U.S. historically have been relatively high compared to world prices. Therefore, in order for the price support program to be effective in the U.S., import restrictions have been established so that the CCC can support domestic milk prices and producers' incomes without having to support world dairy prices as well.
The Federal Milk Marketing Order program was established by the Agricultural Marketing Agreement Act of 1937. Federal orders set minimum prices that must be paid to dairy farmers or their cooperatives for fluid grade (Grade A) milk in markets where producers have chosen to come under Federal orders.

Two major provisions of Federal milk orders are classified pricing by use and pooling or combining all revenues from the sale of regulated milk from which a single uniform or blend price is paid to producers. Milk used for fluid products is designated as Class I. Most orders also include two other classes: Class II milk is used for soft products, such as fluid cream, ice cream, cottage cheese, and yogurt; Class III includes milk used for hard products, which include cheese, butter, and nonfat dry milk.

Minimum prices are established for all of the Federal marketing orders on the basis of specified relationships to the average price of manufacturing grade milk in Minnesota and Wisconsin (M-W price). Therefore, the minimum prices automatically reflect changes in the support prices when market prices are at or below support. Prices for milk used in manufactured products are set at or near the M-W price, while minimum prices for fluid milk products are higher by fixed differentials unique to each Federal order. The basic structure of fluid price differentials was last changed in 1968. In general, the differentials increase with the distance from the upper Midwest (Eau Claire, Wisconsin is the base). Prices increase at a rate of about 15-cents per cwt per 100 miles.

A recurring problem with Federal orders is the extent to which marketing order minimum prices should cover services that cooperatives or marketing agencies perform in seasonal, weekly, and daily balancing of fluid milk supplies with consumption. In some areas, these marketing service costs come out of producer
revenues. In other regions, the cost of providing these services are covered by over-order charges negotiated between cooperatives and fluid milk processors.

Compared to the price support program, milk marketing orders are more complex instruments of government intervention, although government costs of the milk order program are modest. Milk marketing orders have also been successful in guaranteeing participating milk producers a consistent and "fair" price for their product. However, marketing orders have done little to help reduce the current over-production dilemma and in fact, encourage production of grade A milk.

**Objectives**

The purpose of this research is to specify and estimate both the direct and indirect linkages between the U.S. dairy sector and the federal government. This overall objective can be disaggregated as follows:

1. To specify equations which capture the involvement of the government sector in dairy price support program provided by the Commodity Credit Corporation.
2. To account for federal expenditures on the dairy sector and their influence on the general economy.
3. To analyze the impacts of specific changes in dairy policy on both the dairy sector and other sectors of the economy, as well as to provide the framework for examining the impacts of changes in other farm programs on the dairy sector.
Procedures

To account for the linkages between the federal government and the dairy sector, equations will be specified for CCC removals, and their associated costs including storage and handling, total federal expenditures on dairy programs and and their impact on Treasury expenditures. Existing linkages between the dairy sector and other agricultural sectors, such as the beef and feed grain sectors will also be examined in order to accurately reflect the impacts of changes in these markets on dairy producers.

After the dairy model equations have been specified and estimated, they will be incorporated into an existing general equilibrium model of the U.S. economy (COMGEM). The dairy sector equations will then be simulated and verified based on actual data which has been withheld from the estimation process.

Following verification, the model will be used to evaluate the potential impacts of changes in federal dairy programs on the dairy sector and other sectors of the U.S. economy. The proposed framework will be able to account for direct and indirect changes in federal government expenditures associated with proposed policy changes. The model will also provide a useful tool for evaluating the impacts of future changes in general economic policy and other federal farm policies on the dairy sector.

The organization of this thesis is as follows: Chapter 2 summarizes relevant literature pertaining to previous models of the dairy sector. Chapter 3 explains the general form of the model equations. The results of the estimation of the theoretical equations and simulation of different farm policy combinations are discussed in Chapter 4. Chapter 5 summarizes the results obtained from this study and discusses the conclusions drawn from the alternative scenario simulations.
CHAPTER 2

LITERATURE REVIEW

During the last twenty years, numerous studies regarding the dairy industry have been conducted. Building on previous work by Rojko and Halvorson, many studies such as those by Prato, Chen, et. al., and Wilson and Thompson have concentrated primarily on estimating supply and demand elasticities for dairy products. Although these studies provide valuable results regarding the dairy sector, they do not emphasize the implications of federal dairy policy.

Other studies have used the results from the milk supply and demand response studies to analyze the effect of federal dairy policy on the dairy sector. Hallberg proposed a model to study the impact of relaxing government intervention in the dairy sector. Government involvement is represented by a variable Hallberg considered to be largely determined in the political arena. The price of milk received by farmers is a weighted average of the prices received for fluid eligible and manufacturing grade milk. The weights applied to fluid and manufacturing milk prices include the policy variable. The weight of the fluid eligible milk price is given by dividing the demand for fluid milk by the summation of the demand for fluid milk, the demand for manufacturing grade milk, and the policy variable. The weight of manufacturing grade milk is equal to one minus the weight of fluid eligible milk. This specification allows for analysis of the effect of gradually relaxing government involvement in the dairy sector. The main purpose of this study was to estimate the cyclical instability of milk production and prices that
might occur in the absence of existing dairy programs. Using annual data for 1955-78, six different simulations were analyzed. The results showed that more instability would have occurred without government intervention, but the fluctuations would not have been more than were observed for other farm commodities.

To evaluate the possible effects of removing the dairy price support program, Gruebele proposed three model variations based on a number of a priori assumptions including specifications for the price elasticity of demand for milk and the elasticity of supply of milk. Model I estimates the price, income, and production effects of eliminating the price support program. Using a stepwise process, the impact of adding to the commercial market what otherwise would have been government purchases was determined. An elasticity of demand of -0.38 was used to estimate the decrease in prices paid to producers for milk. The second step involves taking into account the responses of producers to lower milk prices. The adjustment was lagged one year and based on a supply elasticity of 0.14. Models IIA and B simultaneously include responses by producers and consumers to changes in milk prices in one equation. In Model IIA, the elasticity of demand was assumed to be -0.28 for fluid milk and -0.5 for manufacturing grade milk. Model IIB assumed an elasticity of demand of -0.18 for fluid milk and -0.40 for manufacturing grade milk. In both models, the elasticity of supply was assumed to be 0.14. No explicit policy variables were described in any of the model variations. The analysis was made in two stages using annual data for 1950-75. The first stage analyzes what the price, income, and structural effects would have been if the price support program had not existed for the past 26 years. In the second stage, projections are made to 1980 under the current programs and also assuming the absence of the dairy price support program. Based on the results of his analysis,
Gruebele's main conclusion is that the price support program has been more price-stabilizing than price-enhancing.

Novakovic and Thompson proposed a model of milk output and price determination to study the impacts of milk imports on the U.S. dairy sector. Policy variables in the model include ending USDA stocks, USDA donations, and USDA purchase prices of American cheese, butter and nonfat dry milk. Production is a function of the blend price of milk which is directly related to the price support of dairy products. This specification does not allow the model to simulate the gradual withdrawal of government involvement. Another possible shortcoming of this model is the specification of the government stocks equations, which are a function of wholesale price, commercial stocks and USDA purchase prices of butter, American cheese and nonfat dry milk. These equations are usually expressed as functions of the support prices for these products to account for the discontinuity of government purchases when market prices are above the support price.

Heien used a model of the dairy industry to estimate the direct cost of federal dairy programs and the indirect costs to consumers due to the increased price of dairy products for the period 1949-1974. CCC purchases of manufactured dairy products was the policy variable used in determining direct costs. Indirect costs were calculated by running the model over the estimated period with the exogenous variables set at their actual levels. Next, the model was rerun with government removals set at zero. This was labelled the "free market" solution. The Consumer Price Index (CPI) for dairy products and also for all commodities was calculated in each run. Based on the assumption that the CPI reflects a true cost of living index, Heien reported an indirect cost of $3.4 billion and a direct cost of $7.1 billion over the 1949-1974 period, an average of $402 million per year. It should be noted, however, that government demand for manufacturing grade milk is
implicitly included in the "free market" solution since the quantity of manufacturing grade milk (including government stocks) is the residual of total milk output and milk eligible for fluid market. Therefore, the "free market" solution is questionable due to the fact that government stocks depend on market clearing and support prices.

Hallberg and Fallert developed a relatively complete policy simulation model of the U.S. dairy industry, which at present is completely recursive and is regionalized on the supply side. Policy variables include parity price for all wholesale milk and the support price, ending government stocks, and government purchases and donations of butter, American cheese and nonfat dry milk. All of these variables are endogenously calculated within the model except for government donations which is exogenous. Producer prices are based on the Minnesota-Wisconsin (M-W) price which is a function of the support price for all milk lagged one quarter, a seasonal adjustment, and a supply-demand adjustment with a one quarter lag. Manufacturing grade milk price is a function of the current value of the M-W price and three quarterly dummy variables to capture seasonal adjustments. The price of fluid milk is based on the M-W price lagged one quarter and quarterly dummies under the assumption that the Class I price differential is constant and included in the intercept term. As in the Heien and Novakovic and Thompson models, this specification of the structural relationships does not allow for simulation of gradually relaxing government intervention.

Reed proposed a quarterly simulation model to test the hypothesis that, given the existing structure of the dairy industry, a support price of 75 percent of parity (rather than the legislated 80 percent) enacted at the start of the 1978-79 marketing year would have significantly reduced the commercial imbalance of 1983. The model is intended to build upon the work of Hallberg and Fallert while
incorporating many aspects of the Food and Agricultural Policy Simulator (FAPSIM). Policy variables include government donations of butter, cheese and nonfat dry milk, support purchase prices of butter, cheese and nonfat dry milk, and the purchase cost of the dairy price support program. All of these variables are generated endogenously with the exception of government donations and support purchase prices of butter, cheese and nonfat dry milk. The determination of the farm blend price for all milk follows the procedure used in FAPSIM and is generally consistent with the Federal order pricing provisions, which establishes minimum and effective Class I prices based on the M-W price, Class I price differentials and over-order payments. The farm blend price is calculated as a weighted average of the Grade A and the Grade B prices of milk sold to plants and dealers. This allows for analysis of gradual elimination of government influence. Again, as in the Novakovic and Thompson model, government stocks are a linear function of lagged stocks, government purchases, government donations and an unaccounted government residual rather than a function of support prices. However, in this model, government purchases are endogenous and are incremented positively or negatively until the wholesale price is equal to or between .99 and 1.1 percent of the support price. This recognizes the relationship between government purchases and the level of market clearing prices relative to support prices.

Westcott also developed a quarterly econometric model of the U.S. dairy sector for use in short- to medium-term outlook and policy analyses. Behavioral equations are estimated for four categories: milk cow inventories, production per cow, commercial use, and farm-level milk prices. An identity equation for net government removals of milk represents the role of government in the dairy sector. This equation also serves as the market-clearing equation and sets net government removals of milk equal to total milk supplies less commercial milk use and ending
commercial stocks. The milk price deduction that producers are assessed and the milk price support are exogenous policy variables that are used to simulate alternative policy assumptions. The farm-level milk price is specified as a function of the support price with slope shifters allowing for seasonality. The effective milk price differs from the farm-level milk price by the amount of the milk price deduction. Neither of these specifications takes into account the relationship between support prices and the market clearing price. Therefore, this model also ignores the discontinuity aspect of government purchases. Properties of the model are analyzed by looking at adjustments to changes in selected variables. Dynamic system multipliers are derived for personal disposable income, feed prices, cattle prices, and milk prices. Westcott uses the model to examine two policy issues. First, the model is used to estimate the effects of the voluntary 15-month paid diversion program included in the Dairy and Tobacco Adjustment Act of 1983. Second, the model is used to examine some implications of three price support policy alternatives, ranging from leaving the price support at its 1984 level of $12.60 per cwt to lowering the price support to $10 per cwt. The analysis suggests that a diversion program policy results in only a temporary and partial solution of the dairy production/consumption imbalance problem. Westcott also concludes that although the results suggest that the price support level can be an effective policy tool, substantial reductions in the current price support levels would be necessary to reduce the government's role in the dairy sector.

Three popular large-scale models which include dairy sector submodels are the National Agricultural Policy Simulator (POLYSIM), the Farm Level Income and Policy Simulation Model (FLIPSIM), and the Food and Agricultural Policy Simulator (FAPSIM).
POLYSIM is a macroeconomic model developed by Ray and Richardson at Oklahoma State University in cooperation with the USDA. The model is based primarily on estimated supply and demand elasticities obtained from a variety of sources and is designed to simulate around a set of baselines values for the endogenous and exogenous variables. The baseline values are developed by commodity specialists who use formal and informal forecasting models along with their experienced judgements. Therefore, the results from this model are dependent upon the reliability of the elasticities and the baseline values.

The dairy portion of the model is contained in the livestock and livestock products section. The dairy equations for milk production and milk price, as well as estimates of the total number of dairy production units and the index of prices received for dairy products are calculated in the same manner as the other livestock groups. Livestock group prices are calculated using one of three price flexibility matrices and computed percentage changes in the quantity available for domestic consumption from their baseline values. Prices are determined by multiplying the selected own- and cross-price elasticity measures by the change in quantity available for domestic consumption, then summed and added to one before being multiplied by the baseline price. A shortcoming of this specification with respect to milk prices is that the dairy price support program is not accounted for. In fact, federal dairy policy is not represented anywhere in the model.

Another important limitation of POLYSIM is that it is a disaggregated agricultural sector model which is completely independent from the rest of the economy. Therefore, linkages to financial and other markets in the general economy in which farmers participate are not captured either recursively or simultaneously.

FLIPSIM is a firm level, recursive simulation model developed by Richardson and Nixon at Texas A&M University. It is designed to simulate the annual
production, farm policy, marketing, financial management, growth and income tax aspects of a case farm over a multiple-year planning horizon. The model can be programmed to simulate either deterministically or stochastically most types of farming situations anywhere in the U.S. and can also simulate the impact of most government farm programs related to specific types of farms.

In the dairy subroutine, annual cash receipts for milk are the product of annual production per cow, number of cows milked and the annual average price received for milk. Annual dairy prices for milk, cull cows, replacement cows and calves, plus the milk production per cow are determined exogenously from either independent or multivariate distributions selected by the analyst. As in the POLYSIM model, federal dairy programs are not represented explicitly in either the dairy or policy subroutines.

The main weakness of this model is that it does not account for the aggregate effects of a given policy which would occur if the model reflected the behavior of all farmers. A further shortcoming is the independence between crop and livestock production and prices when modeling a typical farm. No linkages exist between these two categories and no substitution is allowed. Therefore, the indirect impacts of federal crop programs on livestock production are not accounted for.

Perhaps one of the most complete macroeconomic models to date is FAPSIM, developed by Salathe, Price and Gadson. FAPSIM is a general equilibrium sector model which accounts for both crop and livestock production, as well as most commodity programs currently in use. Endogenous policy variables in the dairy-sector submodel include the minimum Federal order price for Class I milk, USDA beginning stocks and purchases of butter, American cheese and nonfat dry milk, and the total cost of USDA dairy product purchases. Exogenous policy variables which are not computed by other submodels are USDA donations and purchase prices of
butter, American cheese and nonfat dry milk, and the level of imports and exports of dairy products.

The dairy-sector submodel can be divided into four sub-components: milk supply, milk price, milk manufacturing, and commercial demand. Milk prices are based on the M-W manufactured milk products price series. The price of fluid eligible milk is calculated by weighting Class I and Class II prices by the proportion of fluid eligible milk utilized as Class I or Class II. The price of manufacturing grade milk is equal to the current M-W price. Thus, the blend price of milk is calculated by weighting the prices of fluid eligible and manufacturing milk by the proportion of milk produced as fluid eligible and manufacturing grades. Government stocks and purchases are contained in the commercial demand subcomponent. Government purchases are computed as the residual difference between supply and demand. This specification avoids the problem of discontinuity in government purchases due to market clearing prices above the designated support price.

The dairy and other submodel contained in FAPSIM can be used to analyze the effects of alternative dairy price support options on the dairy sector and other livestock and crop sectors. However, as with POLYSIM, FAPSIM does not capture the linkages between the agricultural sector and the rest of the general economy.

All of the models discussed did an adequate job of describing interaction in the dairy sector while also incorporating some form of government intervention. However, none of these models account for the effects of intervention in the dairy sector on the government sector or other sectors of the economy. Several models have tried to capture the linkages between agriculture and the rest of the general economy. Examples of these models include the Wharton Agricultural Sector model discussed by Chen and the AGSEC model proposed by Roop and Zeitner (which can be
run as a small satellite model or integrated into a large macromodel, specifically the Wharton Mark IV). However, both of these models deal only with income and expenditures flows and their linkages with the rest of the economy are achieved through accounting identities. Hughes and Penson also note that these models do not contain equations which would allow them to address questions regarding the direct and indirect effects of national economic policies on the farm sector.

These shortcomings prompted Hughes and Penson to develop a general equilibrium model (GEM) of the U.S. economy which emphasizes agriculture. The model can trace the impacts of changes in fiscal and/or monetary policy on the farm sector simultaneously with other sectors of the general economy. At present, however, GEM is not equipped to handle farm policies that are commodity-specific since there are only two sectors (livestock and crops). Therefore, because federal farm programs are commodity-specific, the model cannot analyze farm policy impacts on agriculture and the rest of the economy.

Romain developed a commodity-specific policy simulation model (COMPOL) to be used in conjunction with the GEM model. The combined model (COMGEM) explicitly accounts for the interactions among six basic sectors in the economy (farm operator families, other domestic consumers, nonfarm businesses, financial intermediaries, government, and the rest of the world) in a fully simultaneous manner. This simultaneous nature allows COMGEM to analyze both the direct and indirect effects of changes in general economic policies as well as agriculture-specific policies on the entire U.S. economy. The addition of the proposed set of equations to complete the linkages between the dairy sector and the government sector will provide the COMGEM model with greater capabilities to assess the impacts of federal farm programs on all sectors of the economy.
CHAPTER 3

THEORETICAL STRUCTURE OF THE DAIRY MODEL

The purpose of this chapter is to discuss the theoretical structure of the dairy sub-sector equations. The model is based upon the equations specified by Romain in 1983. However, since this study emphasizes the intervention of the federal government in the dairy industry and any feedback effects from the dairy sector to the federal government, equations representing this involvement were added to Romain's original model. In addition, the model's original equations were re-estimated using current data and then re-specified as necessary. The first section of this chapter discusses the equations added to represent government involvement in the dairy sector. The rest of the sub-sector's original equations are presented in the last section.

Government Intervention

Federal government intervention in the dairy sector occurs at both the farm and retail levels. Since this study is national, rather than regional, in scope, it focuses on the price support program which directly affects farm prices. The effects of Federal milk marketing orders are treated exogenously as the difference between the price paid to farmers for manufacturing grade milk and the price paid for fluid milk.
The federal price support program guarantees farmers a minimum price for manufacturing grade milk, even though market conditions may be weak and government stocks increasing. This is accomplished by the CCC purchasing excess manufactured dairy products, such as butter, American cheese and nonfat dry milk when market conditions are weak. The CCC also releases stocks of these products back onto the market when market conditions drive the price to a level higher than the announced release price.

There is no quota or limit associated with the price support program. The CCC will purchase any amount of excess dairy products from the commercial market at the specified support price. For this reason, CCC removals of dairy products can be specified as a residual equation.

\[
(3.1) \quad \text{CCCREM}_t = \text{COMMSUP}_t - \text{COMMSTKS}_t - \text{COMMUSE}_t
\]

where:

\[
\text{CCCREM}_t = \text{manufactured dairy products removed from the commercial market by the CCC in period } t,
\]

\[
\text{COMMSUP}_t = \text{total commercial supply of manufactured dairy products available in period } t,
\]

\[
\text{COMMSTKS}_t = \text{ending commercial stocks of manufactured dairy products in period } t,
\]

\[
\text{COMMUSE}_t = \text{commercial disappearance of manufactured dairy products in period } t.
\]

In this specification, total commercial supply of manufactured dairy products is determined by summing dairy products marketed by farms, beginning commercial stocks and imports of manufactured dairy products during the year. Commercial disappearance of dairy products includes domestic consumption, government donations
to the School Lunch and other welfare programs, exports and other uses. This formulation reflects the fact that if dairy products are not utilized commercially or added to commercial stocks, they are removed from the market by the CCC.

Associated with CCC removals of dairy products from the commercial market are the costs related to the purchasing and storing of these products. In order to properly reflect federal expenditures associated with the dairy program, these costs must be explicitly accounted for. The level of CCC purchase costs is a function of the amount of manufactured dairy products removed from the commercial market and the support price which is paid for these products.

\[(3.2) \quad CCCPC_t = f (CCCREM_t, SUPPR_t)\]

where:

\(CCCPC_t\) = the cost of CCC purchases of manufactured dairy products in period \(t\),

\(CCCREM_t\) = CCC removals of manufactured dairy products in period \(t\),

\(SUPPR_t\) = milk price support on December 31 in period \(t\).

Since the support price for milk is determined and announced by the Secretary of Agriculture, the value of \(SUPPR_t\) is treated as an exogenous policy tool in the model. Due to the annual nature of the model, as well as the national scope, the support price used is a national annual average support price. For this reason, the cost of purchases was not specified as an identity because of the difficulty associated with accounting for the timing of purchases and their exact cost.

Once the CCC has purchased quantities of butter, American cheese and nonfat dry milk from processors, these products must be stored until they are donated or sold under government programs or are released back onto the commercial market when
market prices reach a level of 110 percent of the support price. Therefore, the costs of storing and handling the products purchased by the CCC can be specified as an function of the stocks of butter, cheese and nonfat dry milk in storage and the storage rate.

\[(3.3) \quad CCCSC_t = f (AVGSTKS_t, RATE_t)\]

where:

- \(CCCSC_t\) = the storage and handling costs of manufactured dairy products owned by the CCC in period \(t\),
- \(AVGSTKS_t\) = average government stocks of butter, cheese and nonfat dry milk in period \(t\), and
- \(RATE_t\) = weighted average of the storage rates for butter, American cheese and nonfat dry milk in period \(t\).

Government stocks of dairy products are continuously changing due to donations and sales under such programs as the School Lunch Program and P.L. 480, as well as releasing stocks back onto the commercial market when market conditions warrant. The annual nature of the model makes it infeasible to attempt to capture month to month variability in stocks, therefore the average of government stocks in periods \(t\) and \(t-1\) was used in the formulation of storage costs. Because this study deals only with raw milk, rather than individual dairy products, a weighted average of the storage rates for butter, cheese and nonfat dry milk was used to estimate storage costs. The weights were determined by estimating the percentage amounts of each of the three products in total government stocks over the time period under consideration. This procedure is feasible due to the fact that the amounts of butter, American cheese and dry milk are recorded on a milk equivalent basis.
Since a primary interest of this study is to account for federal expenditures on dairy programs, it is necessary to estimate total CCC expenditures on the dairy price support program.

\[(3.4) \quad \text{CCCExp}_t = f (\text{CCCPc}_t, \text{CCCSc}_t)\]

where:

\[\text{CCCExp}_t = \text{CCC total expenditures on dairy programs and related costs in period } t,\]

\[\text{CCCPc}_t = \text{the cost of CCC purchases of dairy products in period } t, \text{ and}\]

\[\text{CCCSc}_t = \text{the storage and handling costs of manufactured dairy products owned by the CCC in period } t.\]

The arguments of this equation represent the two major expenditures associated with the dairy price support program. The CCC purchases any amount of excess dairy products on the commercial market in order to guarantee dairy farmers at least the support price for their milk. Once these purchases have taken place, the CCC must then store the acquired stocks.

During the past several years, much attention has been focused on federal farm programs. High federal deficits have forced policy makers to take a close look at federal spending on farm programs. A general perception of farm programs, and one that is often promoted by the press, is how much these programs cost the government each year. A fact that is frequently overlooked is that the costs of these programs are partially offset by funds which flow back to the government from the farm program receipts typically associated with the sale of government controlled commodities. In order to discuss federal expenditures on farm programs in a realistic manner, both components, receipts as well as expenditures, must be examined. Table 1 shows a breakdown of both the outlays by and the receipts
### Table 1. CCC Net Expenditures for the Dairy Price Support Program, Fiscal Years 1979-1986

(Millions of Dollars)

<table>
<thead>
<tr>
<th></th>
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<tr>
<td>Purchases</td>
<td>246.7</td>
<td>1262.4</td>
<td>1990.7</td>
<td>2282.4</td>
<td>2716.0</td>
<td>1983.2</td>
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<td>79.2</td>
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<td>70.1</td>
<td>77.1</td>
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<td>77.8</td>
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<td>Processing and packaging</td>
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<td>22.1</td>
<td>23.9</td>
<td>30.3</td>
<td>74.6</td>
<td>114.1</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
<td>335.6</td>
<td>630.7</td>
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<td>Termination payments</td>
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<td>n/a</td>
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<td>n/a</td>
<td>n/a</td>
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<td>0.1</td>
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<td>0.2</td>
<td>0.3</td>
<td>76.1</td>
<td>138.6</td>
<td>159.9</td>
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<tr>
<td><strong>SUBTOTAL</strong></td>
<td>298.9</td>
<td>1325.2</td>
<td>2100.8</td>
<td>1347.8</td>
<td>2971.9</td>
<td>2665.3</td>
<td>2822.9</td>
<td>3087.0</td>
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<table>
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<tr>
<th>Offsetting Receipts:</th>
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</thead>
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<tr>
<td>Proceeds from sales</td>
<td>-242.7</td>
<td>-285.4</td>
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<td>-211.3</td>
<td>-118.5</td>
<td>-215.2</td>
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<td>Net transfers to blended foods</td>
<td>-23.2</td>
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<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
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<td>-832.4</td>
<td>-374.6</td>
<td>-287.4</td>
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<tr>
<td>Other</td>
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<td>-0.3</td>
<td>-0.3</td>
<td>-0.3</td>
<td>-31.4</td>
<td>-60.9</td>
<td>-139.0</td>
<td>-161.3</td>
</tr>
<tr>
<td><strong>SUBTOTAL</strong></td>
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<td>-314.1</td>
<td>-207.0</td>
<td>-243.5</td>
<td>-443.8</td>
<td>-1162.9</td>
<td>-738.2</td>
<td>-750.0</td>
</tr>
</tbody>
</table>

| Net expenditures:   | 23.8| 1011.1| 1893.8| 2182.2| 2528.1| 1502.5| 2084.7| 2337.0|

Note: Gross outlay items minus receipt items equal net expenditures (expenditure concept).

n/a = not applicable

Figures may not add due to rounding.

Source: Agricultural Stabilization and Conservation Service, USDA.
accruing to the CCC for the dairy price support program for fiscal years 1979 through 1986.

Gross outlays include not only purchases and storage and handling, but also transportation, processing and packaging. Helping to offset these outlays are receipts associated with proceeds from sales, net transfers to blended foods, and other sources.

Although outlays for the dairy price support program have increased from 1979 through 1986, receipts have also increased, although by a smaller percentage. Contributing to the increase in outlays have been payments for the 15-month paid diversion program during fiscal years 1984 and 1985, and also payments for the dairy termination program in 1986. Partially offsetting the added outlays were receipts from the 50-cent per cwt deduction on all milk marketed which was included in the 1983 Dairy and Tobacco Adjustment Act.

As Table 1 shows, there are substantial receipts as well as costs associated with the dairy price support program. It is therefore necessary to include an equation to account for CCC net expenditures rather than CCC total expenditures related to dairy price support activities. Net expenditures can be expressed as an identity relating outlays and receipts.

\[(3.5) \quad \text{CCCNET}_t = \text{CCCEXP}_t - \text{CCCSALES}_t\]

where:

\(\text{CCCNET}_t\) = CCC net expenditures on dairy price support activities in period \(t\),

\(\text{CCCEXP}_t\) = CCC total expenditures on dairy programs in period \(t\), and

\(\text{CCCSALES}_t\) = CCC receipts due to proceeds from sales of dairy products and other sources in period \(t\).
The average price of milk received by farmers is directly affected by CCC purchases of manufactured dairy products when market conditions are weak and by releases of stocks when market conditions strengthen. Therefore, government intervention is also reflected in the formulation of farmers' expected price of milk. An expected price formulation must account for both possible market conditions just mentioned, as well as for the possibility of gradual government withdrawal from the market due to a continuous shift in the demand curve to the right.

Romain combined the properties of two equations which take into account the above considerations. The first equation represents the minimum expected price for milk in period \( t \), and is given by:

\[
(3.6) \quad PMK^s_t = ( \Sigma_{j=1}^{3} (\frac{PMK^a_{t-j}}{SMK^o_{t-j}}) \ast W^j ) \ast SMK^o_t
\]

where:

- \( PMK^s_t \) = minimum expected average price for milk in period \( t \),
- \( PMK^a_{t-j} \) = average price received for all milk in period \( t-j \),
- \( SMK^o_{t-j} \) = announced price support for milk in period \( t-j \), and
- \( W^j \) = the weights applied to various lags, the weights sum to 1.

This specification indicates that farmers compare the average price received for all milk to the announced price supports in the previous three years, weight them geometrically to emphasize the most recent ratio, and then expect a minimum price with a similar weight. The term minimum is used because this formulation assumes a continuous governmental presence in the dairy sector.
However, equation (3.6) would not appropriately reflect farmers' price expectations if the government were to withdraw from the sector. In this case, the support price ($SMK^0$) would be zero, thereby making the value of $PMK^S_t$ equal to zero also. This formulation also would not be appropriate if there was upward pressure on price due to a shift in demand to the right. In this case, government would probably decide to withdraw gradually and the price support would likely receive less emphasis in farmers' expectations. To account for this, Romain presented the following formulation of an expected price:

\[
(3.7) \quad PMK^m_t = \left( \sum_{j=1}^{3} \left( \frac{PMK^a_{t-j}}{PMK^a_{t-j-1}} \right) \right) \times PMK^a_{t-1}
\]

where:

- $PMK^m_t =$ expected market price for milk in period $t$,
- $PMK^a_{t-j} =$ average price received for all milk in period $t-j$.

This specification is appropriate in the case where strong market conditions would drive the price of manufacturing grade milk above the support price. However, it would not accurately reflect the case in which the support price increases when market conditions are weak.

The expected price formulation specified by Romain and used in this study takes into account the properties of both equations (3.6) and (3.7).

\[
(3.8) \quad PMPS^0_t = \frac{PMK^m_t}{PMK^S_t} \quad (PMPS^0 = 0.0 \text{ if } PMPS^0 < 1.0)
\]

\[
(3.9) \quad WG^0 = \frac{1.0}{(1.0 + PMPS^0)}
\]

\[
(3.10) \quad EFPMK_t = WG^0 \times PMK^S_t + (1.0 - WG^0) \times PMK^m_t
\]
where:

\( \text{PMPS}_t^0 \) = the extent to which the expected market price exceeds the expected price under the price support program in period \( t \),

\( \text{PMK}_t^m \) = the expected market price for milk in period \( t \),

\( \text{PMK}_t^s \) = the expected price for milk under the price support program in period \( t \),

\( \text{WG}_t^0 \) = the weight associated with \( \text{PMK}_t^s \) and,

\( \text{EFPMK}_t \) = the expected average price for all milk in period \( t \).

Equation (3.10) gives the final formulation of the expected price used in this study. This specification combines, in a weighted average formulation, both the government support price and the previous market prices to obtain an expected price for milk. This formulation therefore allows for the simulation of gradual withdrawal of government intervention from the dairy sector and/or the simulation of the effects of an increase in the demand for milk.

Equations (3.1) through (3.5) and equation (3.10) represent the level of government activity in the dairy sector. These equations account for government outlays and receipts associated with the dairy price support program. Feedback effects from the dairy sector to the government are represented by farmers' output response which is determined by the expected price of milk formulation.

The next section presents the rest of the dairy sub-sector equations. These equations complete the model used in this study.
For the benefit of the reader, this section discusses the remainder of the dairy sub-sector model as specified by Romain.

Dairy cow numbers are determined by estimating the slaughter of dairy cows, replacement dairy heifers and the breeding stock of dairy cows.

Total slaughter of dairy cows is an identity which accounts for both commercial and farm slaughter.

\[(3.11) \quad TSLDY_t = CSLDY_t + FSLDY_t\]

where:
- \(TSLDY_t\) = the total slaughter of dairy cows in period \(t\),
- \(CSLDY_t\) = the commercial slaughter of dairy cows in period \(t\), and
- \(FSLDY_t\) = dairy cows slaughtered on farms in period \(t\).

Commercial slaughter of dairy cows is a function of last periods slaughter and breeding stock, all expected output prices, and the implicit rental cost for inputs.

\[(3.12) \quad CSLDY_t = f(DYCOW_{t-1}, CSLDY_{t-1}, FPMILK_t, FPCOW_t, FFEED_t)\]

where:
- \(CSLDY_t\) = commercially slaughtered dairy cows in period \(t\),
- \(DYCOW_{t-1}\) = breeding stock of dairy cows in period \(t-1\),
- \(FPMILK_t\) = the average price received by farmers for all milk in period \(t\),
FPCOW\textsubscript{t} = the average price received by farmers for cows sold in period t,

PFEED\textsubscript{t} = price index for feed in period t.

Farm slaughter of dairy cows is calculated by taking the total farm slaughter of all cows and subtracting the number of beef cows slaughtered.

\begin{equation}
(3.13) \quad \text{FSLDY}_t = \text{FSLALL}_t - \text{FSLBF}_t
\end{equation}

where:

FSLDY\textsubscript{t} = the farm slaughter of dairy cows in period t,

FSLALL\textsubscript{t} = farm slaughter of all cows in period t, and

FSLBF\textsubscript{t} = farm slaughter of beef cows in period t.

Replacement heifers is also an identity which is determined by the net change in breeding stock, the total slaughter of dairy cows, a death loss of 2 percent and the percentage of replacement heifers slaughtered.

\begin{equation}
(3.14) \quad \text{REPDY}_t = (\text{DYCOW}_t - \text{DYCOW}_{t-1}) + \text{TSLDY}_t + (.02 \times \text{DYCOW}_{t-1}) + \text{RSLDY}_t
\end{equation}

where:

REPDY\textsubscript{t} = replacement dairy heifers that entered the herd in period t,

DYCOW\textsubscript{t} = breeding stock of dairy cows in period t,

TSLDY\textsubscript{t} = the total slaughter of dairy cows in period t,

RSLDY\textsubscript{t} = replacement heifers that entered the herd in period t, but were slaughtered in period t.
Breeding stock of dairy cows is estimated as a function of all expected output prices, the implicit rental cost of inputs, the number of cows ready to enter the herd, and the lagged value of the dependent variable to reflect partial adjustment in the model.

\[
(3.15) \quad DYCOW_t = f (FPMILK_t, FPCOW_t, PFEED_t, REPDY_t, DYCOW_{t-1})
\]

where:

- \( DYCOW_t \) = breeding stock of dairy cows in period \( t \),
- \( FPMILK_t \) = the price received by farmers for all milk in period \( t \),
- \( FPCOW_t \) = the price received by farmers for cows sold in period \( t \),
- \( PFEED_t \) = the price index for feed in period \( t \), and
- \( REPDY_t \) = replacement heifers that entered the herd in period \( t \).

Milk production per cow is determined by the implicit rental costs of nondurable inputs, a vector of variables representing technological and biological improvements and the lagged dependent variable to reflect partial adjustment.

\[
(3.16) \quad COWMKPROD_t = f (IRCNDLV_t, TIME, COWMKPROD_{t-1})
\]

where:

- \( COWMKPROD_t \) = milk production per cow in period \( t \),
- \( IRCNDLV_t \) = real implicit rental cost of non-durables associated with livestock production in period \( t \), and
- \( TIME \) = a time trend dummy variable, (1950=1, 1951=2, ...).
Total milk production in period $t$ is determined by the milk production per cow and the average number of dairy cows.

\begin{equation}
\text{MKPROD}_t = \text{COWMKPROD}_t \times \text{AVGDYCOW}_t
\end{equation}

where:
- $\text{MKPROD}_t$ = total milk production in period $t$,
- $\text{COWMKPROD}_t$ = milk production per cow in period $t$, and
- $\text{AVGDYCOW}_t$ = the average number of dairy cows in period $t$.

Milk utilization can be broken down into milk used on farms, other domestic consumers’ demand for both fluid and manufacturing grade milk, and commercial and government stocks. The specification for milk consumed on farms reflects both human and animal consumption.

\begin{equation}
\text{QFDMK}_t = f(\text{AVGDYCOW}_t, \text{FPOP}_t, \text{TIME}, \text{FDISPY}_t, \text{QFDMK}_{t-1})
\end{equation}

where:
- $\text{QFDMK}_t$ = quantity of fluid milk consumed on farms in period $t$,
- $\text{AVGDYCOW}_t$ = average number of dairy cows in period $t$,
- $\text{FPOP}_t$ = farm population in period $t$,
- $\text{TIME}$ = a time trend dummy variable, $(1950=1, 1951=2, \ldots)$, and
- $\text{FDISPY}_t$ = farm operators’ disposable income in period $t$.

Farm population and farmers’ income reflect human consumption. Animal consumption is approximated by the average number of dairy cows on farms. The
lagged value of the dependent variable is included to reflect tastes and preferences. The time trend variable accounts for changes in demand over time.

Domestic demand for fluid and manufacturing grade milk is based on the assumption that consumers maximize utility subject to a budget constraint. The explanatory variables of these equations therefore include prices for commodities in the utility function and disposable income. As in the specification for farm consumption of milk, the lagged value of the dependent variable and the time trend variable are included for the reasons discussed above.

Per capita consumption of fluid milk is specified as follows:

(3.19) \[ QFMKCAP_t = f (RPFLMK_t, PNFOOD_t, PMEAT_t, CDICAP_t, TIME, QFMKCAP_{t-1}) \]

where:

- \( QFMKCAP_t \) = per capita consumption of fluid milk by other domestic consumers in period \( t \),
- \( RPFLMK_t \) = retail price index for fluid milk in period \( t \),
- \( PNFOOD_t \) = price index of nonfood items in period \( t \),
- \( PMEAT_t \) = price index for meat in period \( t \),
- \( CDICAP_t \) = per capita personal disposable income in period \( t \), and
- \( TIME \) = time trend dummy variable, (1950=1, 1951=2, ...).

Total consumption of fluid milk by other domestic consumers is specified as an identity based on per capita consumption and population.

(3.20) \[ QFMKODC_t = QFMKCAP_t \times ODCPOP_t \]
where:

\( QFMKODC_t \) = total consumption of fluid milk by other domestic consumers in period \( t \),

\( QFMKCAP_t \) = per capita consumption of fluid milk by other domestic consumers in period \( t \),

\( ODCPOP_t \) = U.S. non-farm population in period \( t \).

The specification for the consumption of manufacturing grade milk is similar to that for the consumption of fluid milk.

\[ (3.21) \quad QMMKODC_t = f (PMEAT_t, CDI_t, RPMMK_t, QMMKODC_{t-1}) \]

where:

\( QMMKODC_t \) = other domestic consumers’ consumption of manufacturing grade milk in period \( t \),

\( PMEAT_t \) = price index for meat,

\( CDI_t \) = personal disposable income in period \( t \), and

\( RPMMK_t \) = retail price index for manufacturing grade milk in period \( t \).

Ending government stocks can be expressed as total milk production plus the previous period's stocks and imports less milk consumed on farms and that consumed by other domestic consumers.

\[ (3.22) \quad GVSTKS_t = MKPROD_t + GVSTKS_{t-1} + MMK_t - (QFDMK_t + QFMKODC_t + QMKTMMK_t) \]
where:

\[ \text{GVSTKS}_t = \text{ending government stocks of manufacturing grade milk in period } t, \]

\[ \text{MKPROD}_t = \text{total milk production in period } t, \]

\[ \text{MMK}_t = \text{imports of dairy products (milk equivalent) in period } t, \]

\[ \text{QFDMK}_t = \text{fluid milk consumed on farms in period } t, \]

\[ \text{QFMKODC}_t = \text{fluid milk utilized by other domestic consumers in period } t, \]

\[ \text{QMKTMMK}_t = \text{total quantity of manufacturing grade milk that determines prices in period } t. \]

Commercial stocks are specified residually.

\[(3.23) \quad \text{COMMSTKS}_t = \text{COMMSTKS}_{t-1} + \text{QMKTMMK}_t \]

\[ - (\text{QMMKODC}_t + \text{XMK}_t + \text{GVDON}_t)\]

where:

\[ \text{COMMSTKS}_t = \text{ending commercial stocks of manufacturing grade milk in period } t, \]

\[ \text{QMKTMMK}_t = \text{total quantity of manufacturing grade milk that determines prices in period } t, \]

\[ \text{QMMKODC}_t = \text{manufacturing grade milk consumed by other domestic consumers in period } t, \]

\[ \text{XMK}_t = \text{exports of dairy products (milk equivalent) in period } t, \]

\[ \text{GVDON}_t = \text{government donations of dairy products (milk equivalent) in period } t. \]
The price of fluid milk received by farmers is based on the price of manufacturing grade milk. The determination of the price for manufacturing grade milk reflects the quantity of all manufacturing milk that went through marketing channels during the year.

\[ (3.24) \quad FPMMK_t = f ( FPMMK_{t-1}, QMMKTMMK_t, COMMSTKS_{t-1} ) \]

where:
- \( FPMMK_t \) = average price received by farmers for manufacturing grade milk in period \( t \),
- \( QMMKTMMK_t \) = total quantity of manufacturing grade milk that determines milk prices in period \( t \), and
- \( COMMSTKS_{t-1} \) = ending commercial stocks of manufacturing grade milk in period \( t-1 \).

The farm price for fluid milk is given by equation (3.25).

\[ (3.25) \quad FPFLMK_t = FPMMK_t + MARGIN_t \]

where:
- \( FPFLMK_t \) = average price received by farmers for fluid milk in period \( t \),
- \( FPMMK_t \) = average price received by farmers for manufacturing grade milk in period \( t \),
- \( MARGIN_t \) = the difference between the prices received by farmers for fluid and manufacturing grade milk in period \( t \).

Because the differential between the price for manufacturing milk and the price of fluid milk is generally fixed and announced by marketing orders, the value of \( MARGIN \) is treated exogenously in the model.
The average price received by farmers for all milk is a weighted combination of the price received for manufacturing grade milk and the price received for fluid milk.

\[
(3.26) \quad FPMILK_t = \frac{(FPFLMK_t \cdot QFMKODC_t)}{MKPROD_t} + \frac{(FPMMK_t \cdot (MKPROD_t - QFMKODC_t))}{MKPROD_t}
\]

where:
- \( FPMILK_t \) = average price received by farmers for all milk in period \( t \),
- \( FPFLMK_t \) = price received by farmers for fluid milk in period \( t \),
- \( QFMKODC_t \) = fluid milk consumed by other domestic consumers in period \( t \),
- \( FPMMK_t \) = price received by farmers for manufacturing grade milk in period \( t \), and
- \( MKPROD_t \) = total milk production in period \( t \).

For a detailed discussion of the determination of milk prices, see Romain Appendix, pages 231-234.

Cash receipts to dairy producers is specified as follows:

\[
(3.27) \quad CRMILK_t = MKPROD_t \cdot FPMILK_t
\]

where:
- \( CRMILK_t \) = cash receipts from dairy marketings in period \( t \),
- \( MKPROD_t \) = total milk production in period \( t \), and
- \( FPMILK_t \) = average price received by farmers for all milk in period \( t \).
All of the specified equations are solved simultaneously which allows for the interaction between prices and quantities and provides for equilibrium to occur in the dairy sector. When the federal expenditures equations are included with Romain's original equations, a framework has been established which will allow for the examination of the impacts of changes in policy instruments on both the dairy sector and the magnitude of federal expenditures.

This chapter has presented the theoretical foundations considered when specifying the structure of the dairy equations in the model developed in this study. In the next chapter, the empirical estimates of the specified equations, validation of these equations, and simulation of policy alternatives are discussed.
CHAPTER 4

EMPIRICAL ESTIMATION AND SIMULATION OF THE MODEL

This chapter presents the results of estimating the parameters of the equations needed to represent the linkages between the government sector and the dairy sector. Initially, the choice of estimator used in the determination of the estimates is discussed. The second section of this chapter provides an explanation of the sources of data used in constructing the equations. A detailed discussion of the individual equations and their components is presented in the third section of Chapter 4. Estimates of the parameters of the model's original equations which were respecified are also discussed. The final sections of the chapter discuss the validation of the model and the simulation of a policy scenario.

Choice of Estimator

The dairy sector equations estimated in this study must be incorporated into the framework of an existing large scale, annual, macroeconomic model (COMGEM). This model consists of a system of nearly 600 simultaneously determined endogenous equations with approximately 280 predetermined exogenous variables. There has been considerable discussion in the literature as to the best estimation technique to use in estimating equations for inclusion in large scale simultaneous models. The selection of ordinary least squares (OLS) estimation over alternate estimation
procedures has been discussed by Hughes and Penson (1980) and by Howrey, et. al. (1981). Howrey et. al. conducted a survey of well-respected macroeconomic model builders to obtain their views on different types of estimation and validation methods for macroeconomic models. Based on the responses, Howrey found that OLS was a popular estimator although a variety of consistent simultaneous equation estimators have been developed. Respondents noted that although other estimators could be used that reduce bias in the equations, these estimators would also induce more variance or error into the equations and therefore, into the model as a whole. Increased variability frequently leads to convergence problems with large models. However, there are problems associated with using a single equation estimator such as OLS. The disturbance term may be correlated with explanatory variables and therefore, the coefficient estimates would be biased and inconsistent. These problems can be accepted when the alternatives are examined. The use of 2 stage least squares (2SLS) is not feasible in large scale multi-equation models because of the requirement that the number of exogenous variables must be less than or equal to the number of observations. The use of three-stage least squares (3SLS) and full information maximum likelihood (FIML) estimators are precluded when the number of behavioral equations is greater than the number of observations because their required assumptions are violated. According to Theil (1971, p.532), when the number of exogenous variables is greater than the number of observations, as is true in this model, 2SLS and 3SLS estimators do not exist since they require calculation of the inverse of the X'X matrix. The use of OLS for estimating a system of simultaneous equations has also been discussed by Fair (1984) and Hughes and Penson (1980). Fair examined the similarity of the estimates of coefficients given by OLS, 2SLS, FIML, least absolute deviations (LAD) and two-stage least absolute deviations (2SLAD) for a U.S. macroeconomic model. Only 1 of 169 OLS
estimates was more than 1.5 standard deviations away from the 2SLS estimates, a significantly smaller percentage than was true for any of the other estimators. Fair (1984, p.406) also states that if one takes the view that all models are at least slightly misspecified and that the standard statistical properties of the estimators are not valid, then the choice of estimator does not make much difference in terms of better statistical estimates. All authors concluded that OLS estimates performed as well as or better than other types of estimation methods which were underidentified. The equations discussed in this chapter were estimated using the OLS estimation technique. Although this procedure yields asymptotically biased parameters, the use of other estimators was not feasible due to the small number of observations for some of the variables. The estimated equations are reported with their coefficient estimates, the t-statistics indicating the level of significance for hypothesis testing, the $R^2$ value indicating the amount of variability explained, and the Durbin-Watson statistic to evaluate the error structure. Durbin’s h-statistic is reported for equations which include a lagged value of the dependent variable as this is a more powerful test for difference equations.

Data

The primary sources of data pertaining to CCC management of the dairy price support program are the Dairy Division of the Economic Research Service (ERS) and the Agricultural Stabilization and Conservation Service (ASCS).

Information on milk supply and use and beginning commercial and government stocks of dairy products were obtained from the ERS publications *Agricultural Outlook* and *Dairy Outlook and Situation Report*. The use of ending stocks, rather
than beginning stocks, in this study allows other variables to affect these stocks in a simultaneous fashion throughout the time period.

_Agricultural Outlook_ also provides information on the level of CCC removals of manufactured dairy products from the market. The data published in this series verifies that CCC removals can be specified residually. The government purchases a sufficient quantity of manufactured dairy products to support the market price at the previously announced levels. It should also be noted from the data that CCC removals and government stocks are not equal. CCC removals are very likely to be included in ending government stocks, however, the data cannot be reconciled to specify government stocks residually. This is due to the quantities of dairy products that are resold by the government to schools, the military and under special programs. These quantities are not based strictly on demand factors, but also are affected by political decisions.

Information on CCC expenditures for purchases, storage and handling of manufactured dairy products and proceeds from sales were provided by the ASCS. These variables are expressed on a fiscal year basis. It should be noted that the start of the fiscal year was moved from July 1 to October 1 in 1976.

Storage rates for butter, American cheese and nonfat dry milk were also obtained from the ASCS. The rates are expressed as cents per cwt per month. As mentioned in Chapter 3, a weighted average of these storage rates was used in determining CCC storage costs because of the difficulty in accounting precisely for the inflows and outflows of stocks during the course of the year.
Estimation of Parameters

This section discusses the estimated form of the equations added to the original model to represent the linkages between the government and dairy sectors. Any of the model's original equations which were re-estimated are also discussed. Table 2 contains a description of the endogenous and exogenous variables used in this chapter.

The equations, along with their coefficients, t-statistics, $R^2$ values, Durbin-Watson statistics and Durbin's h-statistics are presented in Table 3. Equations (4.1) through (4.3) were added to the original model to represent government involvement in the dairy sector. Equations (4.4) through (4.8) are equations which were respecified and re-estimated.

Equation (4.1) presents the estimated form of CCC storage costs. Storage costs were better estimated by multiplying the lagged value of average government stocks by the storage rate rather than being estimated as a function of both variables. Including the level of stocks in period $t-1$ instead of stocks in period $t$ also provided a better statistical fit. One explanation for this may be that average stocks during last period are a good indicator of what average stocks will likely be in the current period. As with any annual model, it is difficult to accurately account for the variability in stocks levels throughout the year. This specification shows statistical significance and has a high $R^2$ value.

The coefficients of the variables included in the estimation of CCC purchase costs, as shown in equation (4.2), display the theoretically expected signs and the equation as a whole accounts for 90 percent of the variability in purchase costs. Although the coefficient on the support price is not statistically significant,
Table 2. List of Endogenous and Exogenous Variables Used

<table>
<thead>
<tr>
<th>Endogenous variables:</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVGDYDCOW - average number of dairy cows</td>
</tr>
<tr>
<td>AVGSTKS - average government stocks of processed dairy products (milk equivalent)</td>
</tr>
<tr>
<td>CCCEXP - CCC total expenditures on dairy programs and related costs</td>
</tr>
<tr>
<td>CCCNET - CCC net expenditures on dairy price support activities</td>
</tr>
<tr>
<td>CCCPC - the cost of CCC purchases of manufactured dairy products</td>
</tr>
<tr>
<td>CCCREM - manufactured dairy products removed from the commercial market by the CCC (milk equivalent)</td>
</tr>
<tr>
<td>CCCSC - the storage and handling costs of manufactured dairy products owned by the CCC</td>
</tr>
<tr>
<td>CDI - personal disposable income</td>
</tr>
<tr>
<td>CDICAP - per capita disposable income</td>
</tr>
<tr>
<td>COMMSTKS - ending commercial stocks of manufacturing grade milk</td>
</tr>
<tr>
<td>COMMSUP - total commercial supply of manufactured dairy products (milk equivalent)</td>
</tr>
<tr>
<td>COWMKPROD - domestic milk production on a per cow basis</td>
</tr>
<tr>
<td>CRMILK - cash receipts from dairy marketings</td>
</tr>
<tr>
<td>CSLDY - commercial slaughter of dairy cows</td>
</tr>
<tr>
<td>DYCOW - breeding stock of dairy cows</td>
</tr>
<tr>
<td>EFPMK - expected average price for all milk</td>
</tr>
<tr>
<td>FDISPY - farm operator families’ disposable personal income</td>
</tr>
<tr>
<td>FPCOW - average price received by farmers for cows (deflated)</td>
</tr>
<tr>
<td>FPFLMK - average price received by farmers for fluid milk (deflated)</td>
</tr>
<tr>
<td>FPMILK - average price received by farmers for all milk (deflated)</td>
</tr>
<tr>
<td>FPMMK - average price received by farmers for manufacturing grade milk (deflated)</td>
</tr>
<tr>
<td>FSLALL - farm slaughter of all cows</td>
</tr>
</tbody>
</table>
Table 2. Continued

FSLBF  -  farm slaughter of beef cows
FSLDY  -  farm slaughter of dairy cows
GVSTKS -  ending government stocks of manufacturing grade milk
IRCNDLV -  real implicit rental cost of non-durables associated with livestock production
MKPROD -  total domestic production of raw milk
PFEED -  price index of feed (deflated)
PFUEL -  price index of fuel (deflated)
PMEAT -  price index of meat (deflated)
PMKm -  the expected market price for milk
PMKs -  the expected price for milk under the dairy price support program
PMPS0 -  the extent to which the expected market price for milk exceeds the expected price under the price support program
PNFOOD -  price index of non-food items (deflated)
QFDMK -  farm consumption of milk
QFMKCAP -  per capita consumption of fluid milk by other domestic consumers
QFMKODC -  consumption of fluid milk by other domestic consumers
QMKTMMK -  total quantity of manufacturing grade milk that determines prices
QMMKODC -  consumption of manufacturing grade milk by other domestic consumers
REPDY -  replacement dairy heifers that entered the herd
RPFLMK -  retail price index for fluid milk (deflated)
RPMKM -  retail price index for manufacturing grade milk (deflated)
RSLDY -  dairy heifers that entered the herd, but were slaughtered the same period
TBILL -  real rate of return on 3-month Treasury bonds
Table 2. Continued

TSLDY - total slaughter of dairy cows

Exogenous variables:

CCCSALES - CCC receipts from sales of dairy products

COMMUSE - commercial disappearance of manufactured dairy products (milk equivalent)

FPOP - U.S. farm population

GVDON - government donations of agricultural products (deflated)

MARGIN - difference between the prices received by farmers for fluid and manufacturing grade milk (deflated)

MMK - imports of dairy products (milk equivalent)

ODCPOP - U.S. non-farm population

RATE - weighted average storage rate for manufactured dairy products

SUPPR - milk price support on December 31

TIME - time trend dummy variable (1950=1, 1951=2 ...)

WG\(^0\) - the weight associated with the expected price of milk under the price support program

XMK - exports of dairy products (milk equivalent)
Table 3. Estimated Dairy Model Equations

(4.1) CCCSC = 0.150 E 01 + 0.255 E -06 (AVGSTKS\_t-1 * RATE)
\[ (5.88) \]
\[ R^2 = .94 \quad DW = 3.3 \]

(4.2) CCCPC = -0.636 E 02 + 0.522 E -04 CCCREM + 0.194 E 02 SUPPR
\[ (13.9) \quad (0.67) \]
\[ R^2 = .90 \quad DW = 1.9 \]

(4.3) CCCEXP = 0.88 E 01 + 0.704 E 01 CCCSC + 0.916 E 00 CCCPC
\[ (5.32) \quad (21.9) \]
\[ R^2 = .99 \quad DW = 1.7 \]

(4.4) COMMSTKS = -0.329 E 07 + 0.186 E 07 EFPMK - 0.19 E 07 PFUEL + 0.56 E -01 QMMKODC\_t-1 + 0.347 E 08 TBILL
\[ (4.53) \quad (-2.07) \quad (2.18) \]
\[ R^2 = .84 \quad DW = 2.4 \]

(4.5) DYCOW = 0.179 E 03 + 0.102 E 01 DYCOW\_t-1 - 0.164 E 00 TSLDY + 0.302 E 02 SUPPR/PFEED
\[ (31.4) \quad (-2.48) \quad (3.12) \]
\[ R^2 = .99 \quad DW = 1.0 \quad Dh = 2.7 \]
Table 3. Continued

\[
\begin{align*}
(4.6) & \quad \text{QFMKODC} = 0.263 \times 10^0 + 0.635 \times 10^0 \text{QFMKODC}_{t-1} - 0.417 \times 10^5 \text{TIME} - 0.125 \times 10^7 \text{FPMILK} \\
& \quad (7.74) \quad (-2.83) \quad (-3.14) \\
& \quad R^2 = .85 \quad DW = 2.0 \quad Dh = 0.0 \\

(4.7) & \quad \text{GOVSTKS} = -0.117 \times 10^0 + 0.423 \times 10^0 \text{GOVSTKS}_{t-1} + 0.23 \times 10^7 \text{SUPPR} + 0.733 \times 10^0 \text{CCCREM} \\
& \quad (5.84) \quad (5.35) \quad (8.84) \\
& \quad R^2 = .95 \quad DW = 1.7 \quad Dh = 0.8 \\

(4.8) & \quad \text{FPMMK} = 0.133 \times 10^1 + 0.216 \times 10^0 \text{FPMMK}_{t-1} - 0.552 \times 10^5 \text{QMKTMMK} - 0.662 \times 10^0 \text{COMMSTKS}_{t-1} \\
& \quad + 0.697 \times 10^0 \text{SUPPR} \\
& \quad (1.57) \quad (-1.42) \quad (-1.53) \quad (6.72) \\
& \quad R^2 = .95 \quad DW = 2.2 \quad Dh = -1.0 \\
\end{align*}
\]

Note: Coefficients are reported in exponential notation, i.e. 0.12 E 04 equals 1200.0
this variable was included to provide a policy linkage with which to affect purchase costs in the future.

Total expenditures by the CCC on the dairy price support program are estimated as a function of storage and handling costs and purchase costs. This variable was specified as an estimated equation rather than an identity because various expenditures, such as transportation and administrative costs, were not included as variables in the equation due to the unavailability of data. As can be seen in equation (4.3) in Table 3, both of these coefficients are statistically significant and explain virtually all of the variability in total CCC dairy expenditures.

Romain originally specified commercial stocks as being residually determined (equation (3.23)). However, the nature of the federal dairy programs shows that the level of CCC removals is determined residually. The amount removed from the market is determined by the quantity necessary to support the market price at the specified level. Therefore, it is not feasible or even theoretically sound to express the level of commercial stocks in a residual fashion. For this reason, it was necessary to respecify this equation as the estimated form given in equation (4.4). This specification allows processors and dealers to base the level of commercial stocks in the current period on the expected price for all milk, the price index for fuel, the quantity of manufacturing grade milk consumed by other domestic consumers in the previous period, and the real return on 3-month Treasury bonds. The expected average price for all milk is included as an indicator of the price for manufacturing grade milk. It is reasonable to assume that if the price of manufacturing grade milk and, therefore, the price of manufactured dairy products is expected to increase, dealers and processors would keep more of these stocks on hand. This theory is supported by the sign and significance of the parameter. The price index for fuel was included in this specification as a proxy for energy
costs, such as refrigeration and transportation of the manufactured dairy products in stock. This coefficient is statistically significant and has the expected sign. The quantity of manufacturing grade milk consumed by other domestic consumers is lagged one period in order to act as an indicator of expected demand for manufactured dairy products in the current period. The sign of this parameter implies that consumption in the previous period positively affects stocks this period. It is not unreasonable to assume that consumption in the current period will be greater or at least the same as that in the previous period. Theory might suggest a negative sign associated with the coefficient on the 3-month Treasury bond rate. However, since this rate is only a short-term rate, it is considered as a leading indicator of interest costs. In this case, the positive sign of this parameter is acceptable, as commercial stocks would increase during the current period in anticipation of continuing increases in future interest costs. A lagged value of the dependent variable might also be expected to be included in the specification. This variable was included in several regressions with various combinations of variables. However, the coefficient was never found to be statistically significant and inclusion of this variable did not improve the statistical fit of the equation.

Romain considered the breeding stock of dairy cows to theoretically be a function of the prices received for milk and cows, the price index for feed and replacement dairy heifers (equation (3.15)). However, the final estimated form of this equation included only the lagged value of the dependent variable and commercial slaughter of dairy cows. This equation was re-estimated in the form shown in equation (4.5). This specification also includes a lagged value of the dependent variable, which is highly significant and contributes a great deal to the excellent fit of this equation. This formulation uses total slaughter of dairy
cows rather than commercial slaughter and includes a ratio for the support price of milk relative to the price of feed as an indicator of output prices relative to input prices. Both of these parameters are significant and display the theoretically expected signs.

The quantity of fluid milk consumed by other domestic consumers was originally specified as an identity (equation (3.20)). The final form of this equation, however, is an estimated function of the dependent variable lagged one period, a time trend dummy variable and the U.S. population. This formulation was respecified, as shown in equation (4.6) of Table 3, to include the average price of all milk rather than the population since the coefficient of U.S. population was not statistically significant. The coefficient of the average price of milk is significant and has the correct sign. This change also improved the fit of the equation. The quantity of fluid milk consumed during the current period is positively related to consumption last period and negatively related to the time trend variable. The negative sign associated with the time trend variable may be explained by the theory that as the population grows older, people consume less fluid milk and may also be related to the increased availability of substitute drink products.

Government stocks of manufacturing grade milk were estimated by Romain in a residual fashion (equation (3.22)). However, as was pointed out in the discussion of the data section of this chapter, the level of CCC removals is determined residually. Determining government stocks residually is not supported by the data. Equation (4.7) presents the estimated form of the government stocks equation. The current level of government stocks is a function of government stocks in the previous period, the support price of milk and the level of CCC removals. Each of
these variables is theoretically reasonable and their coefficients are statistically significant and display the correct signs.

The specification of the price received for manufacturing grade milk was altered slightly to include the support price for milk. The price support basically provides a floor under the price of manufacturing grade milk, and therefore, under the price of all milk. As indicated in equation (4.8), the coefficient of this variable is highly significant compared to the other parameters and therefore, is a major factor contributing to the high statistical fit of the equation.

This concludes the presentation of the estimated equations which provide the necessary framework to assess the impact of government intervention in the dairy sector, as well as the re-estimated equations designed to improve the overall accuracy of the model. In the following section, the equations presented will be simulated out of sample in order to examine the ability of these specifications to accurately reflect costs and expenditures associated with the federal dairy program.

**Validation of Equations**

To examine the predictive ability of the equations discussed in the previous section, it was necessary to simulate outside of the sample period and compare the estimated values to the actual data. In this study, data for 1985 and 1986 were excluded from the sample period used to estimate the model. Therefore, the estimated equations can be simulated over the 1985-1986 period for validation purposes.
When evaluating simulation models, difficulties arise in determining how to test the "goodness" of the model. In the evaluation process, one must decide if the structural specification of the model is reasonable and whether the coefficients make sense and indicate the appropriate direction of change. The model's evaluation must also depend on the purpose for which the model was built. According to Pindyck and Rubinfeld (1976), a model designed for forecasting purposes should have as small a standard error of forecast as possible. In the case of a multi-equation simulation model, the evaluation criteria become more complicated. Because there are multiple equations, high statistical significance for some equations may have to be balanced against low statistical significance for other equations. Pindyck and Rubinfeld (p. 315) state that the model as a whole having a dynamic structure which is richer than any one of the individual equations is the most important consideration. Finally, they note that it is possible that some of the equations will fit the data well while others will not.

One criterion used to evaluate simulation models is the performance of the individual variables in a simulation context. One method of testing this performance is to perform a historical simulation and examine how closely each endogenous variable tracks its corresponding data series. Another method is to simulate the equations beyond the estimation period and then evaluate how closely the equations track the actual values for given years. One measure that is often used in both instances to ascertain the validity of specified equations is the root-mean-square percent error (RMSPE), which is defined by Pindyck and Rubinfeld (p. 316) as:

\[
\text{RMSPE} = \left( \frac{1}{T} \sum \left( \frac{(Y_s^t - Y_a^t)}{Y_a^t} \right)^2 \right)^{1/2}
\]

where:

- \(Y_a^t\) = actual value of \(Y\) in period \(t\),
\( Y_t^S = \) simulated value for \( Y \) in period \( t \), and

\( T = \) the number of periods in the simulation.

The root-mean-square percent error is a measure of the deviation of the simulated variable from its actual time path in percentage terms, which corrects for the magnitude of the variable, as well as the direction of the error.

The RMSPE for the newly specified equations of the dairy sector model are reported in Table 4. The first category is comprised of the costs associated with CCC management of the dairy price support program. The RMSPE over the simulation period is approximately 3 percent for the costs of CCC purchases of manufactured dairy products. The error for storage and handling costs is nearly twice that for purchase costs, which is not unexpected since the amount of stocks held during the year is highly variable. However, the level of this error is still quite low.

The error associated with total expenditures by the CCC for dairy price support activities is also reported in Table 4. A 17 percent error in forecasting total expenditures seems quite reasonable considering the fact that various expenditures, such as transportation and administrative costs, were not included in the equation due to the unavailability of data.

The RMSPE is also provided for the stock of dairy cows. An error of 5.5 percent is excellent given the fluctuation of herd size during recent years due to such programs as the voluntary paid diversion program and the Dairy Termination Program.

A summary of the errors associated with ending commercial and government stocks of manufactured dairy products is also given in Table 4. A forecast error
Table 4. Validation Results of Selected Variables

<table>
<thead>
<tr>
<th>Category</th>
<th>RMSPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCC Costs</td>
<td></td>
</tr>
<tr>
<td>Purchases</td>
<td>3.23</td>
</tr>
<tr>
<td>Storage and Handling</td>
<td>5.91</td>
</tr>
<tr>
<td>CCC Total Expenditures on the Dairy Price Support Program</td>
<td>17.21</td>
</tr>
<tr>
<td>Stocks of Dairy Products</td>
<td></td>
</tr>
<tr>
<td>Commercial stocks</td>
<td>24.14</td>
</tr>
<tr>
<td>Government stocks</td>
<td>16.86</td>
</tr>
<tr>
<td>Other</td>
<td></td>
</tr>
<tr>
<td>Domestic Consumption of Fluid Milk</td>
<td>3.54</td>
</tr>
<tr>
<td>Price of Manufacturing Grade Milk</td>
<td>1.64</td>
</tr>
<tr>
<td>Stocks of Dairy Cows</td>
<td>5.49</td>
</tr>
</tbody>
</table>
of 24 percent for commercial stocks appears quite reasonable since in an annual model, it is difficult to exactly track stocks, which are continuously fluctuating. Processors and dealers can sell stocks of dairy products to the CCC for the specified support price at any time during the marketing year in order to keep milk prices from falling. If milk prices increase, dealers and processors can release stocks onto the commercial market or decide to keep more stocks in anticipation of continuing high prices. A forecast error of approximately 17 percent for government stocks is also reasonable considering the quantities of dairy products which are resold or donated by the government throughout the year.

The 3.5 percent forecast error associated with consumption of fluid milk by other domestic consumers assures that this equation will not induce significant error into the other equations which depend upon this variable. The same is true for the error in the price of manufacturing grade milk. Because the price received for fluid milk and the average price for all milk are based on the price of manufacturing grade milk, it is necessary for this error to be as small as possible. This in turn, reduces the error associated with the model as a whole.

All of the errors discussed above are below 25 percent. It would be desirable to have lower errors for CCC total expenditures and both commercial and government stocks of dairy products. However, several variations were tried for each of these equations and the RSMP errors did not improve significantly without affecting the statistical fit adversely.

Simulation of the Model

The major purpose of estimating the equations described in this study is to provide a consistent framework within which to evaluate the impact of changes in
different national policy instruments on the dairy sector and other farm sectors, as well as the general economy. The equations discussed earlier in this chapter provide the linkages between the dairy sector and the government sector. Now that these equations have been estimated and their performance validated, the next step is to endogenize them into the COMGEM model and simulate the expanded model under differing assumptions with regard to farm policy.

Before alternative policy scenarios can be analyzed, it is necessary to establish a baseline projection over the simulation period for purposes of comparison. The important objective in policy analysis is not necessarily the forecasting ability of each individual variable, but rather the ability of the entire model to project changes in direction and magnitude of variables when policies are changed. Therefore, it is necessary to establish a reasonable baseline simulation initially. The baseline developed in this study covers the 1986-1989 period, which coincides with the period covered by the current farm bill. Selected baseline results are presented in Table 5. The baseline assumes a continuation through 1989 of the relatively high federal budget deficits, coupled with a monetary policy that holds the rate of inflation in the 2 to 3 percent range throughout the period. The real rate of growth in the economy is maintained in the 2 to 4 percent range over the simulation period. Levels of real interest rates remain in the 3 to 7 percent range throughout the four year period.

Farmers fare poorly under continuing high deficits and a monetary policy which is sensitive to the rate of inflation. Low levels of inflation keep the cost of production inputs at a relatively low level while interest expenses remain relatively constant. Despite the alleviation of cost pressure from the input side, farm prices remain fairly low and real net farm income improves only slightly over this period.
With regard to the dairy sector, reductions in the support price for milk specified in the 1985 farm bill, are reflected in declining values of stocks of dairy cows, CCC removals of dairy products, purchase and storage costs, commercial stocks of manufactured dairy products, milk prices and cash receipts for milk products over the 1986-1989 period. Consumption of fluid milk by other domestic consumers increases slightly over this period, most likely due to lower milk prices and an increase in the birth rate.

Due to the reductions in crop loan rates and the milk price support implemented in the 1985 farm bill, the sum of total direct and indirect expenditures for farm programs drop slightly over the 1986-1989 period. Total federal government expenditures to farmers minus the tax revenues received by the federal government from farm operators defines the farm program deficit, which is a better indicator of taxpayer outlays for federal farm programs. The farm program deficit would fall significantly from 1986 to 1988 primarily due to the projected drop in farm program expenditures. This variable would remain relatively constant from 1988 through 1989.

Policy Simulation

The baseline simulation is based on the major provisions of the 1985 farm bill. These provisions include reductions in the support price for milk each year from 1986 to 1989, as well as the Dairy Termination Program, in an effort to alleviate the current production/consumption imbalance. The Dairy Termination Program has been somewhat effective in reducing stocks of dairy cows, and therefore, total milk production. However, these variables did not decline
<table>
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<tr>
<td></td>
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<tr>
<td><strong>Growth in Real GNP</strong></td>
</tr>
<tr>
<td>(percent)</td>
</tr>
<tr>
<td>2.9</td>
</tr>
</tbody>
</table>

| **Change in GNP Deflator**                                   |
| (percent)                                                    |
| 2.5  | 3.3  | 2.6  | 2.3  |

| **Real Rate on 3-Month Treasury Bills**                      |
| (percent)                                                    |
| 3.4  | 5.9  | 7.2  | 7.2  |

| **Real Federal Budget Deficit** (billion 1967 $)              |
| 61.8 | 42.9 | 48.1 | 57.9 |

| **Real Total Federal Tax Receipts** (billion 1967 $)          |
| 246.0 | 273.7 | 284.7 | 288.3 |

| **Real Total Federal Expenditures** (billion 1967 $)          |
| 308.0 | 316.6 | 332.8 | 346.1 |

| **Total Direct Plus Indirect Expenditures on Farm Programs** (billion $) |
| 26.3 | 24.6 | 22.1 | 24.0 |

| **Farm Program Deficit** (billion $)                          |
| 15.8 | 15.5 | 12.0 | 13.9 |

| **Real Net Farm Income** (billion 1967 $)                     |
| 11.7 | 13.5 | 15.2 | 14.7 |

| **Total Cash Receipts from Crops** (billion $)                 |
| 67.3 | 53.0 | 71.8 | 69.6 |

| **Total Cash Receipts from Livestock** (billion $)             |
| 71.8 | 74.8 | 70.9 | 69.9 |
|------|---------------------------------------------|--------------------------------------------------|----------------------------------------------------------|---------------------------------------------------------|-------------------------------------------------|---------------------------------|-----------------------------------------------|---------------------------------------------|---------------------------------|---------------------------------|
| 1986 | 110.0                                       | 2.20                                             | .051                                                     | 3.09                                                   | 2.34                                           | 10.5                            | 512.0                                         | 434.0                                       | 11.40                           | 11.52                           |
| 1987 | 75.5                                        | 1.38                                             | .046                                                     | 1.63                                                   | 0.90                                           | 10.1                            | 533.6                                         | 373.2                                       | 11.28                           | 11.34                           |
| 1988 | 58.4                                        | 1.08                                             | .030                                                     | 1.24                                                   | 0.54                                           | 9.8                             | 545.4                                         | 279.9                                       | 10.60                           | 12.03                           |
| 1989 | 40.0                                        | 0.74                                             | .015                                                     | 0.82                                                   | 0.14                                           | 9.5                             | 555.8                                         | 223.9                                       | 10.10                           | 11.39                           |
Table 5. Continued

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Farm Price</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>for All Milk ($/cwt)</td>
<td>12.50</td>
<td>12.41</td>
<td>13.15</td>
<td>12.53</td>
</tr>
<tr>
<td>Cash Receipts for Milk</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>and Milk Products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(billion $)</td>
<td>17.80</td>
<td>17.12</td>
<td>17.87</td>
<td>16.84</td>
</tr>
</tbody>
</table>
enough to sufficiently affect the current over-production situation. This may be due to the fact that many participants were those producers who would most likely have exited the industry in the next two or three years or producers who culled older and less productive herds.

This study analyzes the effects of reducing the support price for milk an additional 25 cents per cwt from the levels specified for 1988 and 1989 in the 1985 farm bill. The support price for milk is determined by the Secretary of Agriculture and is generally set at a level between 75 percent and 90 percent of parity. The additional reductions discussed in this study do not conflict with these specifications. Table 6 summarizes the deviations of the dairy sector variables from their baseline simulation values due to the 25 cent per cwt reduction in the support price for milk. It is important to recognize that given the structure of the model, initial policy changes have a dynamic or cumulative effect over subsequent years when lagged values of the dependent variables are included in the specification.

The additional reductions in the price support cause the stock of dairy cows to decline slightly more than in the baseline simulation. However, these cows are most likely the least productive cows, as can be seen from the very small effect on total milk production.

Although milk production is not significantly reduced, CCC removals fall an additional 0.5 and 3.0 percent during 1988 and 1989 under the simulated assumptions. Milk production is based at least in part on the expected price of milk, which is partially dependent upon the announced support price. As support levels decline and milk production falls somewhat, the CCC is required to purchase a smaller quantity in order to support prices at the required level. As would be expected, the decrease in removals lowers purchase and storage costs. Storage
Table 6. Percent Deviations from the Baseline Simulation for Selected Dairy Sector Variables

<table>
<thead>
<tr>
<th></th>
<th>1988</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support Price of Milk</td>
<td>-2.4</td>
<td>-2.5</td>
</tr>
<tr>
<td>Stock of Dairy Cows</td>
<td>-0.1</td>
<td>-0.1</td>
</tr>
<tr>
<td>Total Milk Production</td>
<td>-0.03</td>
<td>-0.09</td>
</tr>
<tr>
<td>CCC Removals of Dairy Products</td>
<td>-0.5</td>
<td>-3.0</td>
</tr>
<tr>
<td>CCC Purchase Costs for Dairy Products</td>
<td>-0.9</td>
<td>-3.6</td>
</tr>
<tr>
<td>CCC Storage and Handling Costs for Dairy Products</td>
<td>0.0</td>
<td>-6.6</td>
</tr>
<tr>
<td>CCC Total Expenditures on Dairy Price Support</td>
<td>-0.8</td>
<td>-3.7</td>
</tr>
<tr>
<td>CCC Net Expenditures on Dairy Price Support</td>
<td>-3.7</td>
<td>-22.3</td>
</tr>
<tr>
<td>Domestic Consumption of Fluid Milk</td>
<td>0.09</td>
<td>0.2</td>
</tr>
<tr>
<td>Farm Price of Manufactured Milk</td>
<td>-1.1</td>
<td>-2.5</td>
</tr>
<tr>
<td>Average Farm Price of All Milk</td>
<td>-1.1</td>
<td>-2.2</td>
</tr>
<tr>
<td>Cash Receipts from Milk and Milk Products</td>
<td>-1.1</td>
<td>-2.3</td>
</tr>
</tbody>
</table>
costs are not affected until 1989 due to the fact that this variable is a function of lagged rather than current stocks. The reduced costs are reflected in reductions in both total and net expenditures on the dairy price support program. The fact that net expenditures are affected more than total expenditures is most likely due to increased sales of dairy products by the CCC as market prices decline below the release level.

The farm price of manufacturing grade milk, and therefore, the average price of all milk declines an additional 1 to 2 percent from the baseline values. Domestic consumption increases slightly more, but cash receipts fall an additional 1 and 2 percent during 1988 and 1989 due to the combined effects of lower production and lower prices.

Table 7 summarizes the deviations of selected macroeconomic variables from their baseline simulation values. As expected, the major macroeconomic variables do not reflect any impact from the 25 cents per cwt decline in milk support prices during 1988 and 1989. If the magnitude of the decline was greater or was sustained for a longer period of time, we would anticipate that some impact would be seen in total federal government expenditures and the cost of financing federal government borrowing. This reaction would certainly be expected if support price levels for crops were reduced as well as those for milk. Also, if the federal budget deficit were significantly smaller, it would be more likely to indicate the effect of a small change in farm program policy. However, since all farm program expenditures currently account for only 1.5 percent of total government expenditures, it is unlikely that any significant impact would be indicated.

Total direct plus indirect expenditures on farm programs fell slightly in 1988 and significantly in 1989 when compared to original baseline values. These
Table 7. Percent Deviations from the Baseline Simulation for Selected Macroeconomic Variables

<table>
<thead>
<tr>
<th></th>
<th>1988</th>
<th>1989</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth in Real GNP</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Change in GNP Deflator</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Real Rate on 3-Month Treasury Bills</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Real Federal Budget Deficit</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Real Tax Receipts</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Real Total Expenditures</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Total Direct Plus Indirect Expenditures on Farm Programs</td>
<td>-3.6</td>
<td>-23.3</td>
</tr>
<tr>
<td>Farm Program Deficit</td>
<td>-6.7</td>
<td>-38.0</td>
</tr>
<tr>
<td>Real Net Farm Income</td>
<td>0.0</td>
<td>-0.7</td>
</tr>
</tbody>
</table>
declines are due to reductions in CCC removal costs and associated storage and handling costs for purchased milk products. Additionally, indirect costs, primarily interest expenses associated with government borrowing of funds used to pay for these programs, fall as the total amount borrowed for farm programs falls. Tax revenues collected from farmers remain almost constant since farm income remain virtually unchanged. The farm program deficit showed relatively significant declines, especially in 1989 due to reduced expenditures. Real net farm income declined slightly during the 1988 through 1989 period due to declines in cash receipts for milk and milk products of 1 percent and 2 percent respectively, while production expenses remained essentially unchanged.

The policy scenario analyzed in this section implies that additional reductions in the price support for milk are needed in order to start bringing the current production/consumption imbalance back into line. It can also be seen that even small reductions in individual components of the farm program, such as the price support for milk, can have an impact on the magnitude of federal expenditures on farm programs. Small reductions in some price supports can be made without significantly affecting real net farm income, but reductions in all price supports would have to be simulated in order to determine the cumulative effect on federal expenditures and the financial stability of the farm sector. Although federal farm program costs comprise only a small portion of total government expenditures, the effects on the farm sector of reducing these expenditures may be quite severe.
CHAPTER 5

SUMMARY AND CONCLUSIONS

This chapter will present a brief summary of the focus and objectives of this study. The results obtained and the conclusions reached during the course of this study are also reported. Proposals for further research which would extend the findings of this study and provide additional insight into the interaction between the dairy sector and government sector are also discussed.

Summary

The initial purpose of this study was to examine the linkages between the dairy sector and the government sector and to provide a consistent framework which can be used to assess the impact of changes in dairy policy on both the dairy and government sectors, as well as on the general economy.

A review of the history of dairy programs was presented in Chapter 1. The two major programs in effect in recent years have been the dairy price support program and Federal milk marketing orders. This study analyzed only the price support program, while treating milk marketing orders exogenously. This is due to the regional nature of marketing orders which cannot easily be accounted for in a national model. A review of previous studies was discussed in Chapter 2. Most of these studies addressed dairy policy in a partial equilibrium setting rather than placing it within the context of both the farm sector and the general economy. The
incorporation of policy linkages into a macroeconomic model is necessary in order
to fully assess the effects of dairy policy changes.

The primary focus of this study was to specify the linkages between
expenditures within the dairy sector associated with federal farm programs and the
costs to taxpayers of instituting or modifying these programs. The incorporation
of linkages required the specification and estimation of equations which account
for the flow of funds into the dairy sector associated with the CCC commodity
programs, as well as accounting for the costs of storing and handling purchased
milk products. Additionally, it was necessary to recognize that a portion of the
CCC removals are resold to schools, the military and other uses under specific
federal programs. Therefore, net expenditures became more important than did total
expenditures for price support operations. A re-examination of other price and
quantity equations was necessary to maintain consistency within the dairy
sub-sector. The theoretical framework of the equations needed to capture
government involvement in the dairy sector, as well as the equations originally
specified by Romain, are reported in Chapter 3.

Chapter 4 presents the estimated form of the model equations along with their
coefficients, t-statistics, \( R^2 \) values, Durbin-Watson statistics and Durbin's
h-statistics. Validation of the equations and policy simulation are also discussed
in Chapter 4. All of the equations estimated have a root-mean-square percent error
of less than 25 percent. Many of the newly specified equations yielded
root-mean-square percent errors of less than 10 percent, indicating that the
equations performed well in projecting values outside of the estimation period.
This is important for a simulation model as the error in one equation can induce a
compounding effect on many other equations and render a non-converging model.
After the equations were incorporated into the existing macroeconomic model (COMGEM), a baseline scenario was obtained for 1986 through 1989. The purpose of the baseline is to institute a given set of monetary and fiscal policy variables and observe the results before any changes in farm or other types of policy are examined. The baseline used for this study assumes a continuation of relatively high federal deficits combined with a fairly moderate monetary policy. This provides for a 1 to 3 percent annual rate of growth in GNP while limiting inflation to less than 4 percent annually. The baseline values for all variables are used for comparison purposes after a policy change has been implemented and simulated for the same 1986-1989 period.

Reducing the support price for milk an additional 25 cents per cwt over the levels specified for 1988 and 1989 in the 1985 farm bill was the policy option chosen for analysis using the newly incorporated linkages. The reduced support prices showed no change at the macroeconomic level in total federal government expenditures, the budget deficit, or the Treasury bill interest rates which indicate the costs of financing expenditures. This result is not unexpected when one considers that farm program expenditures typically account for less than 2 percent of total federal expenditures. The farm sector does show some impact of these small policy changes. Cash receipts for milk and milk products declined slightly, as did the stock of dairy cows and total milk production. The expected future price of milk fell as the announced support price declined. These price declines would be expected to induce producers to reduce herd size, especially of less productive animals.

Costs to the government begin to decline as the CCC is required to remove less milk products from the market in order to maintain market prices at the support level. Sales under various government programs remain relatively unchanged and
storage costs decline as CCC stocks levels fall. These factors combine to reduce CCC net expenditures on dairy programs between 3 percent and 22 percent over the 1988 through 1989 period.

As net expenditures for dairy programs are reduced, total expenditures on federal farm programs decline as well, while real net farm income remains virtually unchanged. The declines in milk production are almost totally offset by improvement in the average price of milk and reductions in costs to producers.

Although the changes in milk price supports analyzed in the policy simulation have little impact on total costs to the taxpayers, there is a small reduction in the costs associated with federal farm programs while real net farm income levels are maintained within an acceptable range.

Conclusions

The linkages incorporated in the macroeconomic model to account for the federal expenditures on dairy programs provide a consistent framework within which to analyze a variety of policy options. The policy scenario examined in Chapter 4 demonstrates that changes in policy variables influence decisions within the dairy sector and the farm sector. Had the policy changes been combined with reductions in price supports for crops, it is likely that changes would have occurred in some of the macroeconomic level variables as well. These linkages provide an important component in finishing the specification of the flow of funds from the federal government to the farm sector related to federal farm programs, as well as the flow of funds back to the government from the dairy sector in terms of CCC sales of dairy products and tax receipts paid by farmers. The improvement in this portion
of the model allows for a better accounting for both the direct and indirect costs associated with federal dairy programs and the ultimate burden borne by U.S. taxpayers.

**Proposals for Further Research**

This study identified the linkages needed to represent federal government involvement in the dairy sector. This allows for the assessment of the likely consequences of various changes in farm policy on all sectors of the U.S. economy. Time limitations and uncertainties associated with forecasting macroeconomic variables in an election year prevented simulation beyond 1989 in this study. One possible suggestion for further research is to simulate the model through 1990 or 1991 and examine the effects of continued lower price supports for milk and other policy scenarios, such as changes in the price supports or loan rates for crops.

Genetic engineering has made it possible to synthetically produce bovine Somatotropin (bST), a protein occurring naturally in cattle, at commercially attractive prices. Cows produce more milk at less cost when injected with bST. Injections of bST during the milking cycle increases milk production significantly without any apparent short-term effect on cow health or quality of milk. Currently, research is being conducted on how well bST works and whether it is harmful to animal health in the long term, however, bST will be commercially available in 1990. The model presented in this study could be used to analyze the effects of bST on the dairy sector and the government sector.

This model can also be of further use in determining the direction and magnitude of changes resulting from policy proposals that entail restrictions on production or payment limitations before such policies are instituted. This would
reduce government costs associated with implementing programs which do not accomplish the intended objectives and allow policy makers to anticipate fully the impacts of proposed changes in federal farm program policy.
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