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A DESCRIPTION OF AN ECONOMETRIC MODEL OF U.S. DAIRY FARM AND PRODUCT MARKETS

by

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and

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Preface

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Introduction

The purpose of this publication is to document an econometric model of the U.S. dairy sector. The conceptual model is discussed. The estimation technique and procedures followed in developing the statistical model are discussed. Validation tests of the model are presented. Sample simulations of the model are shown to illustrate its capabilities. The paper begins with a review of previous efforts to model supply and demand in the dairy sector.

A Review of the Literature

There has been a considerable amount of research done with respect to the supply of raw milk and the demand for dairy products. Using methodological techniques ranging from econometrics to mathematical programming to pure description, the types of models employed have varied a great deal. Although studies of consumption or production in the dairy industry date back 50 years or more, only the literature of the last 20 years is surveyed.

There is a vast number of studies of consumption and production of milk that are purely descriptive in nature, but which still provide insights into the factors affecting supply and demand forces in the dairy industry. Such studies include Jeffery and Feldman (44), Kottke (50), Burk (8) and Hammond and Graf (34).

Much of the econometric work done on the dairy industry has concentrated on identifying supply functions for raw milk. Among those who have developed single equation models of the farm supply of milk are Barker (5), Chen, Courtenay and Schmitz (10), Cochrane (12), Halvorson (31, 32), Hammond (34), Harrington (35), Kadlec, Jensen, and Kehrberg (45), Ladd and Winter (52), Paris (58), Ruane (65), Schuh (68), and Wipf and Houck (73).[1/] There have also been a

[1/] Numbers in parenthesis correspond to the citation number in the Bibliography.

few system of equations models of the supply for raw milk, such as Criner (13), Elterich and Johnson (20), Elterich and Masud (21), and Zepp and McAlexander (75), as well as some single equation models of milk production functions, such as Dean (19), Hoepner (39), and Heady, Madden, Jacobsen and Freeman (36).

Similarly, there is also a large body of literature dealing with econometric models of demand for dairy products, typically the demand for fluid milk and/or manufactured milk products as an aggregate. Single equation demand models have been estimated by Boehm (6), Bullion (7), Gineo (27), Hu (41), Kinnucan (46, 47, 48), Lu and Marshall (53), Morehart (54), Perkins, Clark, and Marshall (59), Purcell (61), Purcell, Raunikar and Elrod (62), Raunikar, Purcell, and Elrod (63) and Shefrin and Yankowsky (69). The classic study in this area was done by Rojko (64), who developed a single equation model for the farm level demand for milk and a systems model of the demands for fluid milk products and manufactured milk products.

As econometric techniques became more refined and computational difficulties decreased, a number of simultaneous systems models of supply and demand were developed. Research in this area has been done by Cromarty (14), who pioneered this type of research with his model of U.S. agriculture, as well as by others who limit their research to the dairy sector, such as Chou (11), Goldman (28), Heien (37), Hutton and Helmberger (42), Sahi and Harrington (66), Prato (60), Salathe, Price and Godson (67), and Wilson and Thompson (72).

Wilson and Thompson were the first to formulate and estimate a simultaneous equation model in which supply and demand are jointly determined. They specify and estimate equations for (1) number of milk cows; (2) yield of milk per cow; (3) quantity of fluid milk demanded; (4) butterfat content of the milk produced; (5) farm milk prices; (6) retail milk prices.

In their model, using annual data, the supply of milk is conceptualized as the product of the number of cows and yield per cow. Per capita demand is conceptualized in three parts, i.e., the per capita demand for fluid milk products in milk equivalent units, the per capita demand for butterfat in manufactured dairy products, and the per capita demand for nonfat solids in manufactured dairy products. The model gives primary emphasis to the solid components determining the value of milk in manufactured uses. All functions in this study are linear and were estimated using two stage least squares (2SLS).

Prato (60) formulated a simultaneous system of supply and demand equations for dairy products. His conceptualization of the model is quite similar to that of Wilson and Thompson. He expands on their work by segregating consumer demand and retail prices into separate equations for fluid products, milkfat and solids-not-fat. Other differences between the two models are the slightly different selection of explanatory variables and data and Prato's somewhat more detailed specification of demand.

Chou (11) examines alternative supply and demand formulations and estimation procedure and ultimately selects a simple 2SLS model of farm level supply and demand. Based on the implied farm level price elasticities of supply and demand, Chou then discusses the impacts of alternative price levels under the price support program.

Drawing directly upon the work of Prato, Hutton and Helmberger specify a four-equation simultaneous system of farm level supply and demand. Their model is designed specifically to test the impact of various policy scenarios on the distribution of costs and benefits in dairy markets. Using 2SLS and annual data for the period 1951-77, they estimate equations for supply of raw milk, per capita fluid milk consumption, per capita consumption of fat solids, and per capita consumption of solids-not-fat. All prices are assumed to be exogenous to the model.[2/] The estimate of supply and demand elasticities for fluid milk and milk components is central to their analysis.

Sahi and Harrington's (66) annual model of the Canadian dairy industry is composed of seven types of equations, as follows:

1. supply response equations for each of three sectors--fluid milk, manufacturing milk and cream farms,
2. processors' demand equations for milk,
3. technical relationships between milk and milk products,
4. consumers' demand functions for dairy products,
5. international trade in specialty cheeses,
6. price relationships between market levels and between evaporated milk and butter,
7. identities and accounting equations.

Sahi and Harrington identified their model as block recursive such that ordinary least squares (OLS) was applied to ten equations and 2SLS was used on a simultaneous block of three equations.

Goldman's (28) quarterly model is among the more detailed models of the U.S. dairy industry. The model is divided into nine major parts, representing the following different types of relationships:

1. consumer demand for fluid milk, butter, cheese, nonfat dry milk, evaporated and condensed milk, frozen products, and margarine,
2. U.S. removals of butter, cheese, nonfat dry milk, and evaporated and condensed milk,
3. U.S. Government domestic donations of butter, cheese, and nonfat dry milk,

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[2/] The blend price received by farmers is calculated using the estimate of milk supply and a predetermined value of total dairy farm receipts.

4. shipments of butter, cheese, nonfat dry milk, and evaporated and condensed milk under government programs,
5. ending commercial stocks of butter, cheese, and nonfat dry milk,
6. net commercial exports of butter, cheese, nonfat dry milk, and evaporated and condensed milk,
7. retail-wholesale price relationships for butter, cheese, and evaporated and condensed milk,
8. supply functions at wholesale for butter, cheese, nonfat dry milk, evaporated and condensed milk, and frozen products,
9. identities relating the supply and utilization of butter, cheese, nonfat dry milk, evaporated and condensed milk, frozen products, and milk available for manufactured products.

A key characteristic of Goldman's work is that, because the model is a quarterly model, the supply of raw milk was treated as a predetermined variable, i.e., it was considered to be a function of only lagged prices. Goldman's model was estimated using 2SLS.

The work of Salathe, Price and Godson (67) also represents one of the more detailed econometric models of the dairy sector currently available. Their model was developed as the dairy sector submodel of the USDA's Food and Agricultural Policy Simulator (FAPSIM). The model draws closely from the work of Novakovic and Thompson (57) and expands upon some of the policy analysis capabilities of their model (as does the current model presented in this report). The dairy subsector model of the FAPSIM contains sets of equations for milk supply, milk manufacturing, milk price, and commercial demand. The model fully integrates the production, manufacture, and consumption of dairy products, specifically, fluid milk, evaporated milk, frozen desserts, butter, American cheese and nonfat dry milk.

An important element of the model by Salathe et al. is the inclusion of equations to estimate government stocks and purchases of supported dairy products. Their specification of the equations for government purchases attempts to resolve the problem of discontinuity in purchases when market clearing prices are above the designated support price. They resolve this problem by specifying government purchases as the residual difference between supply and demand. The residual value is dependent on the calculation of a free market price. If this price is below the price support level, the market price is set equal to the support price and government purchases are calculated as the difference between supply and utilization at that price.

The models of Goldman, Sahi and Harrington, and Salathe et al. represent a noteworthy departure from the earlier efforts of Wilson and Thompson and of Prato. These researchers developed models that looked at individual products as they appear in different market levels, whereas Prato, and Wilson and Thompson implicitly assumed that the supply of raw milk is somehow transformed into a butterfat or solids-not-fat adjusted milk equivalent aggregate for which consumers have a demand.

The model developed in the following pages is based directly on the previous work of Novakovic and Thompson (57), which also identifies distinct products and market levels. Some of the conceptual structure of the model was retained, although all equations were respecified. Major changes include a revision of the structure of the raw milk subsector and an expansion of the policy analysis capabilities of the model. The work of Salathe, Price and Godson (67) provided helpful insight into specifying accounting equations for net removals.

A Caveat on How to Conceptualize Federal Dairy Price Supports

The model reported here differs from the others that have been discussed in many specific ways; however the key difference is in its conceptual formulation with respect to the dairy price support program. With the exception of Salathe et al., all of the analysts share a common conceptual problem--they either ignore or incorrectly incorporate the price support program in their models.

Wilson and Thompson totally ignore this important program. Prato states that he assumes an unregulated market structure; however he estimates the price of manufacturing grade milk to be primarily determined by the support price for manufacturing grade milk. Although he claimed to ignore the support program, he models it as creating a perfectly elastic demand for milk at a level slightly greater than the support price for manufacturing grade milk. The estimation statistics indicate a strong correlation between the support price and the market price; however the depiction of a federally induced, perfectly elastic farm level demand is at best a crude approximation of how the support program works. Strictly speaking it is the wrong conceptual model.

Chou follows a similar path in that his simple model does not explicitly incorporate price support variables but he clearly assumes that the support price for milk sets the farm price. He explicitly represents it as a perfectly elastic farm level demand. Again, this is inaccurate.

Hutton and Helmberger appear to accurately describe the affect of the support program when they state (p.8): "In order to take into account the support program for manufacturing milk into account, we need only observe that D_{11} [Class II demand] can be shifted to the right through government removals of dairy products from commercial channels." However, they go on to say (p.8): "In this manner the government can assure that P_{11} [the Class II price] will not fall below whatever target level is specified." Although they correctly refer to the support price as a target, they incorrectly state that the government assures that the support price will be realized in the market place. Moreover, they go on to say that: "Because of serious constraints on the extent to which the government can remove dairy products from commercial channels it is not by any means clear that a support program could or would offset the downward pressure on P_{11} caused by classified pricing." This is a curious statement in that if the serious constraints to which they refer exist, these impediments are not well documented or known to the dairy industry. To be sure the government sets standards for the products that they buy and the form in which they must be sold, but these do not appear to constitute serious constraints. Consider for example that in 1983 the CCC purchased approximately 29% of the American cheese produced, 32% of the butter, and 70% of the nonfat dry milk. Even more important than this is the implication that the government somehow sets a level of purchases to achieve a particular support target. For example, Hutton and Helmberger's model has no support price variables, and they represent change in price support policy by simply changing the magnitude of CCC purchases. While net removals clearly do change with changes in policy, the implied causality is essentially reverse of what it should be.

These differences in the conceptualization of the price support program are common among econometric model builders and among those who have analyzed federal dairy policy on a more theoretical or conceptual level, .g. Buxton (9) and Whipple (70).

The way the dairy price support program operates is as follows.[3/] The Secretary of Agriculture (or more recently Congress legislatively) sets a support price for manufacturing grade milk. In so doing, it becomes his

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[3/] This discussion focuses on the dairy product purchasing aspect of the dairy support program. Direct producer assessment, the Milk Diversion Program, and the National Dairy Promotion and Research Order, which were recently added, are ignored. Although these clearly have an impact, they do not change how one should conceptualize the traditional price support activities. For further details on current dairy policy see Novakovic (56).

responsibility to take action to ensure that the market price for the equivalent grade of milk does not go below the support price. In other words, achieving at least the support price level becomes the goal or target of support policy. To achieve this goal USDA, through the Commodity Credit Corporation (CCC), purchases storable manufactured dairy products--specifically American cheese, butter, and nonfat dry milk--at wholesale prices that are intended to result in farm prices for milk equivalent to at least the support level. It calculates wholesale level purchase prices for these manufactured products according to formulas containing the support price and an estimate of manufacturing cost for the respective product. The latter are called make allowances by USDA. This strategy assumes that a processor receiving the purchase price for a product sold to the CCC will cover his manufacturing costs and return a price to farmers that is equivalent to the support price.

Upon announcing its purchase prices, USDA stands ready to purchase any quantity of the respective manufactured products (meeting specified quality and packaging standards) that commercial processors wish to offer for sale. Thus the USDA essentially represents perfectly elastic and infinite (at least for all intents and purposes) demands for American cheese, butter, and nonfat dry milk at the wholesale level. Assuming that purchase prices are above market clearing levels, these higher wholesale prices shift the commercial demand for milk at the farm level to the right. If USDA has gauged processor behavior correctly and set purchase prices accordingly, then the shifted farm demand should equate with farm supply in the neighborhood of the support price for milk. This is by no means assured. For example, the annual average price of Grade B milk has been well below the support price since 1980. This is primarily due to the fact that USDA has not changed its make allowances since October 1979; hence the purchase prices are too low to shift farm demand sufficiently to result in a market price as high as the support price. Conceptual or empirical models that explicitly or implicitly assume that the support price represents a perfectly elastic demand at the farm level cannot accurately account for events such as have occurred over the last three years. Novakovic and Thompson and, Salathe et al. recognized this in their models. As will be described in the next section, the model presented herein also more properly reflects the actual instruments and procedures used to effect dairy price support policy and improves upon previous specifications.

Description of the Model

The dairy policy model developed herein consists of three main parts. The dairy product submodel contains five sets of equations representing the wholesale and retail level markets for each of five dairy product groups: fluid milk, American cheese, butter, nonfat dry milk and frozen desserts. The raw milk submodel contains six equations that determine the farm level supply of raw milk. The final submodel consists of equations that measure macro level performance for government purchases, producer income and consumer expenditures. This submodel also contains the equation that links supply to utilization and thereby closes the model.

The full statistical model utilized in this analysis contains 40 equations: 9 identities and 31 stochastic equations. There are 40 endogenous and 38 exogenous variables. The estimation is based on annual data for 1956 to 1981.

The coefficients of the model were estimated using two-stage least squares (2SLS). Because the number of exogenous variables is greater than the number of observations, the first stage of the estimation could not be accomplished using the standard procedure. Principal components analysis was used to estimate an instrument matrix based on all exogenous and lagged endogenous variables. This instrument matrix was then used for the second stage of this estimation.

All statistical procedures were carried out using the Cornell implementation of the TROLL econometrics package. The model was estimated as described in the conceptual form; however, some equations were subsequently re-specified with additions or deletions of variables or a change in functional form. These procedures are included in the discussion that follows.

After a final form for the equations was derived, the model was simulated over the historical (ex post) period, 1958-81. In comparing the simulated values to the actual, some equations exhibited serious specification errors. These equations were re-specified and re-estimated to improve the quality of the simulation.

A test of the model's stability was done by performing a full dynamic simulation for the 49-year period 1982-2030 in which all exogenous variables were held constant at their 1981 level. This test revealed other specification problems that necessitated re-estimating an equation in the raw milk sector.

In the following pages each submodel is described in turn. In presenting these submodels, a brief conceptual framework will be given in order to formulate the theoretical underpinnings of the model's structure. This will be followed by the specification of each equation and a description of the statistical procedure utilized in achieving the final form.

The Conceptual Dairy Product Submodel

In this submodel, the following standard sources and uses of milk products are identified:

Uses: retail demand

year-end commercial stocks

year-end government stocks

USDA donations and other special program use

military consumption

exports and shipments

Sources: production

imports

beginning commercial stocks

beginning government stocks

Not all of the above apply to each individual product submodel. For example, no annual stocks are held for fluid milk products and frozen desserts. These modifications will be made after the more general, theoretical model is explained.

The first step of the model formulation is to decide which variables will be considered endogenous and which are treated as exogenous to the model. The following variables will be treated as exogenous, because they are primarily determined by factors outside of the market for dairy products that is to be described:

1. imports
2. USDA donations and other special program use
3. military consumption
4. exports

The remaining variables, which are determined by forces in the dairy market, are considered to be endogenous:

1. quantity demanded by consumers
2. year-end commercial stock levels

3. year-end government stock levels
4. quantity supplied by processors
5. retail price
6. wholesale price

Hence the basic submodel consists of six equations which explain the simultaneous determination of the six endogenous variables.

Retail Demand

The quantity demanded at retail of the i^{th} dairy product is taken to be a function of all product prices and income. Assuming separability between the product, its competitors, other food products, and nonfood products, the following demand function can be written:

$$QiRD = g_{1i}(PiR, CPIS, CPIAF, CPINF, Y)$$

where

i	=	fluid milk, frozen desserts, American cheese, butter, and nonfaty dry milk,
QiRD	=	quantity of the i^{th} dairy product demanded at retail,
PiR	=	retail price of i^{th} product,
CPIS	=	index of prices of substitute products,
CPIAF	=	index of prices of all other food products,
CPINF	=	index of prices of all nonfood products,
Y	=	disposable income.

Commercial Stocks

Commercial stocks are held at the end of a year for several reasons. One explanation for year-end stocks is based on the concept that certain carryover is desired for the next year, based on anticipated sales in that year. This is a transactions demand for stocks.

Second, stocks may also be held for speculative reasons. This rationale suggests that stock levels are considered to be responsive to the price expected to occur in the future vis-a-vis the current price. Representing the opportunity cost of capital invested in stock, interest rates should affect the degree of responsiveness to the expected price.

Finally, part of the stocks remaining at the end of a year represents a residual of planned inventories and actual inventories used. That is, ending stocks represent the difference between the amount of stocks that were expected to be used and the amount actually used.

The above three explanations are not mutually exclusive. If it is believed that all three explanations play a role in determining year-end stock levels for a dairy product, then stocks would be a function of the following factors:

- expected sales in the current period (t)
- expected sales in the future period (t+1)
- expected prices in the future period (t+1) relative to current prices.

Several points merit clarification before a specific equation can be proposed. The discussion above specifies transactions demand for stocks to be proportional to sales. This may be reflected in a dairy stocks model by including the quantity of the dairy product demanded at retail and exported in the current period. In the case of speculative stockholding, it is hypothesized that two prices are influential in the general dairy product case--the wholesale price and the government purchase price of the product. The purchase price is included with the conventionally used wholesale price because stockholders can always liquidate their inventories by selling to the government at the guaranteed purchase price. Generally, the wholesale price is greater than the purchase price; however, manufacturers can and will sell to the government even at times when the average wholesale price is greater than the purchase price.

The above can be incorporated into the following mathematical description of dairy stocks:

$$SiC = g_{2i}(QiRD^*, QiRD^*_{t+1}, Xi^*, Xi^*_{t+1}, PiW^*_{t+1}, PiW, PiS^*_{t+1}, PiS, RC)$$

where

i = American cheese, butter, and nonfat dry milk,

SiC = year-end commercial stocks of the i^{th} dairy product,

QiRD* = expected quantity of the i^{th} dairy product demanded at retail,

Xi* = expected exports of the i^{th} dairy product.

PiW* = expected wholesale price of the i^{th} dairy product,

PiW = actual wholesale price of the i^{th} dairy product,

PiS* = expected purchase price of the i^{th} dairy product,

PiS = actual purchase price of the i^{th} dairy product,

RC = commercial interest rate.

Expected variables are not observed; however, the above model can be transformed such that all variables are observable. A common assumption is that expectations are formed as a function of lagged observations. Mathematically, this is expressed as follows:

$$QiRD^*_{t+1} = \alpha_0 + \alpha_1 QiRD + \alpha_2 QiRD_{t-1} + \ldots.$$

$$Xi^*_{t+1} = \beta_0 + \beta_1 Xi + \beta_1 Xi_{t-1} + \ldots.$$

$$PiW^*_{t+1} = \gamma_0 + \gamma_1 PiW + \gamma_2 PiW_{t-1} + \ldots.$$

$$PiS^*_{t+1} = \delta_0 + \delta_1 PiS + \delta_2 PiS_{t-1} + \ldots.$$

These expressions can be substituted into the stocks function and then simplified by the Koyck transformation (see Kmenta [49, p. 475]). Doing so yields the following stocks function:

$$SiC = g_{2i}(PiW, PiS, QiRD, QiRD_{t-1}, Xi, Xi_{t-1}, RC, SiC_{t-1})$$

Government Stocks

The U.S. Government is involved in holding stocks because of its price support program. The Commodity Credit Corporation (CCC) of the U.S. Department of Agriculture will purchase any acceptable American cheese, butter, or nonfat dry milk products that are offered for sale and will pay prices that are based on the support price for milk. In principle, if the purchase price exceeds the market clearing price of a supported product, then the purchase price represents a perfectly elastic and infinite demand and market price will equal the purchase price. This will be true until commercial demand increases or supply decreases sufficiently to induce a higher market clearing price, at which time the product will presumably be withdrawn from the government market. In practice, the observed wholesale price typically fluctuates at or above the purchase price, while products can be and are sold to the government at all times.

In the current model, government stocks are specified as a residual market for products not utilized in other areas (i.e., retail demand, donations, exports, military consumption) or held as commercial stocks.

The equation for government stocks is an identity that sets stocks equal to the difference between the sums of sources and uses of the product:

$$SiG = QiWS + Mi + SiC_{t-1} + SiG_{t-1} - QiRD - SiC - Di - Xi - QiM$$

where

i = butter, American cheese and nonfat dry milk,

SiG = year-end government stocks of the i^{th} product,

QiWS = wholesale supply of the i^{th} product,

Mi = imports i^{th} product,

QiRD = retail demand for i^{th} product,

SiC = ending commercial stocks of the i^{th} product,

Di = USDA donations of the i^{th} product,

Xi = exports of the i^{th} product,

QiM = military use of the i^{th} product.

Wholesale Supply

The equation describing the wholesale supply of a dairy product follows the conventional supply theory derivation. In general, the supply of a product is a function of the product's price and the prices of all other products and factors of production. In the dairy product submodel it is assumed that the only relevant product prices are the prices of the various dairy product groups. Hence the wholesale supply model can be expressed in the following mathematical form:

$$QiWS = g_{3i}(PiW, PjW, ZW)$$

where

i,j = fluid milk, frozen desserts, American cheese, butter, and nonfat dry milk ($i \neq j$),

QiWS = quantity of i^{th} product supplied at wholesale,

PjW = vector of dairy product prices not including i^{th} product price,

ZW = vector of wholesale level input prices.

Wholesale Price

The U.S. support price system enters the model through the wholesale price equations for cheese, butter and nonfat dry milk. The wholesale price for these products is estimated as a function of the respective purchase price alone.

$$PiWS = g_{4i}(PiS)$$

where

i = butter, American cheese, and nonfat dry milk,

PiWS = wholesale price of the i^{th} product,

PiS = U.S. government purchase price of the i^{th} product.

It is expected that wholesale price is either greater than or equal to the purchase price. The wholesale price will never fall below the purchase price, as long as purchase prices are set above equilibrium price levels, because demand is infinitely elastic at the purchase price; the U.S. government agrees to purchase all products offered at the announced purchase prices.

This relationship is not expressed as an identity, however, because the wholesale butter, nonfat dry milk and American cheese available for sale are not all manufactured in the grade or package size that makes these products eligible for government purchase. It is expected that wholesale price follows the purchase price very closely, but these prices are not identical.

Retail Equilibrium Condition

To insure equilibrium in and between the wholesale and retail levels a link must be established between wholesale and retail prices. This is accomplished through an equation expressing retail price as a function of the wholesale price and a vector of distributor level factor prices, i.e.,

$$PiR = g_{5i}(PiW, ZR)$$

where

ZR = a vector of retail level input prices.

The General Dairy Product Submodel

The following summarizes the general specification that will be applied to each dairy product class:

retail demand: $QiRD = g_{1i}(PiR, PIS, PIAF, PINF, Y)$

commercial stocks: $SiC = g_{2i}(PiW, PiS, QiRD, QiRD_{t-1}, Xi, Xi_{t-1}, RC, SiC_{t-1})$

government stocks: $SiG = QiWS + SiC_{t-1} + SiG_{t-1} + Mi - QiRD - SiC - Di - Xi - QiM$

wholesale supply: $QiWS = g_{3i}(PiW, PjW, ZW)$

retail price: $PiR = g_{4i}(PiW, ZR)$

wholesale price: $PiWS = g_{5i}(PiS)$

Specification and Estimation of the Dairy Product Submodel

Fluid Milk Submodel

The fluid milk submodel consists of three equations for retail demand, retail price, and wholesale supply. There is no stock equation in this submodel because fluid milk stocks held for transactions purposes are insignificant.

The equation for retail demand expresses retail consumption of fluid milk (QFMRD) as a function of retail price (PFMR) and income (Y) deflated by the Consumer Price Index for non-food (CPINF). A trend variable is included to account for changes in preferences and other unknown factors over time. Retail price is specified as a function of Class I price (PI) and the retail wage rate (WR). The submodel is closed with an identity which sets wholesale production (QFMWS) equal to retail consumption (QFMRD) and donations (DFM).

The final estimates of the fluid milk equations are as follows:[4/]

$$\underset{(11.44)}{QFMRD = 105529.} \; \underset{(-2.60)}{-30037.9} \; PFMR/CPINF \; \underset{(-0.75)}{-334.3} \; Y/CPINF \; \underset{(-6.40)}{-531.1} \; TIME$$

$(R^2 = .95)$

[4/] The R^2 and t-value test statistics will be shown for each estimated equation. Both serve as only approximate statistical indicators when applied to 2SLS estimates. All variables are defined in Appendix 1.

$$PFMR = \underset{(10.67)}{17.9} + \underset{(5.03)}{4.8}\ PI + \underset{(1.61)}{2.9}\ WR$$

$$(R^2 = .99)$$

$$QFMWS = QFMRD + DFM$$

American Cheese Submodel

The cheese submodel consists of five stochastic equations: retail demand, retail price, wholesale supply, wholesale price, and commercial stocks; the submodel is closed with an identity for government stocks.

Retail consumption (QACRD) is specified as a function of own price (PACR), price of substitutes (CPIMPF, CPINF) and income (Y), all deflated by the consumer price index for non-food (CPINF). The initial estimation resulted in a perverse sign on own-price. Novakovic (56) suggests that the positive sign on cheese price could reflect correlation with changing tastes that are not accounted for in the price of substitutes. A time trend was added to correct the problem; however, multi-collinearity then led to high standard errors on the estimated parameters. A new functional form was estimated expressing all exogenous variables as a ratio with retail price. The following specification estimated well, each variable having low standard errors and the expected sign.

$$QACRD = \underset{(1.51)}{716.1} + \underset{(3.48)}{1436.5}\ CPIAF/PACR + \underset{(7.44)}{131.7}\ Y/PACR \underset{(-2.07)}{-509.3}\ CPIMPF/PACR$$

$$\underset{(-5.10)}{-1392.5}\ CPINF/PACR$$

$$(R^2 = .95)$$

A simulation of the full model indicated that, when compared with actual values, this formulation consistently underestimated cheese consumption in the late 1970s to early 1980s. The equation was reformulated. Income (Y) and consumer price index for meat, poultry and fish (CPIMPF) were deleted, and the square root of trend (TIMSQR) was added. The final form of this equation is:

$$\text{QACRD} = \underset{(-8.17)}{-.7127.2} + \underset{(3.98)}{728.9}\ \text{CPIAF/PACR}$$

$$\underset{(-2.67)}{-554.7}\ \text{CPINF/PACR} + \underset{(12.80)}{973.4\ \text{TIMSQR}}$$

$$(R^2 = .98)$$

Wholesale price (PACW) is expressed as a function of the purchase price (PACS). The intercept was omitted because of an insignificant t-value. A binary variable for 1973-74 is included to account for a large shift in price during those years, perhaps due to price controls of that period.

$$\text{PACW} = \underset{(97.86)}{1.04}\ \text{PACS} + \underset{(3.00)}{7.9}\ \text{DUM7374}$$

$$(R^2 = .99)$$

The retail price equation for American cheese is a margin equation expressing retail price (PACR) as a function of wholesale price (PACW) and retail wage (WR):

$$\text{PACR} = \underset{(4.16)}{4.58} + \underset{(1.72)}{0.22}\ \text{PACW} + \underset{(4.57)}{12.2}\ \text{WR}$$

$$(R^2 = .99)$$

The estimation looks very good; however, a problem was discovered in the simulated values for the ex ante period (beyond 1981). The large positive coefficient on retail wage causes extreme increases in retail cheese price in spite of nearly constant wholesale price. Over time the model predicted consistent increases in price and consequently a reduction in retail demand. A large gap between production and consumption resulted. It was decided to remove retail wage (WR) in spite of the significant t-value. The final estimation is:

$$\text{PACR} = \underset{(3.88)}{5.42} + \underset{(41.34)}{.80}\ \text{PACW}$$

$$(R^2 = .99)$$

Wholesale production (QACWS) of American cheese is expressed as a function of wholesale price (PACW), prices of inputs (PGB and WW) and prices of other dairy products (PACW, PBW). The initial estimation of this equation was:

$$\begin{aligned} QACWS = {} & \underset{(4.18)}{1263.5} - \underset{(-2.22)}{2.17}\,PACW - \underset{(-1.23)}{9.8}\,PBW + \underset{(2.77)}{576.7}\,PGB + \underset{(5.73)}{427.9}\,WW \\ & - \underset{(-1.39)}{16.9}\,PNDMW - \underset{(-1.96)}{7.8}\,PICW \\ & (R^2 = .98) \end{aligned}$$

There is a high degree of multicollinearity among the variables and consequently some of the signs are opposite theoretical expectations. The sign on own-price is expected to be positive, whereas price of Grade B milk and wholesale wage (inputs) should be negatively related to wholesale supply. The apparent multicollinearity was reduced by successively eliminating PNDMW, WW, PICR, and PGB; the resulting estimation has expected signs and low standard errors.

$$\begin{aligned} QACWS = {} & \underset{(7.81)}{710.64} + \underset{(8.06)}{15.94}\,PACW - \underset{(-1.19)}{3.10}\,PBW \\ & (R^2 = .95) \end{aligned}$$

Commercial stocks of American cheese (SACC) are specified as a linear function of wholesale production (QACWS), purchase price (PACS), the change in retail demand (QBRD) and exports (XAC), interest rates (RC) and lagged stocks.

$$SACC = g_2(PACWS,\ PACS,\ (QBRD-QBRD_{t-1}),\ (XAC - XAC_{t-1}),\ RC,\ SACC_{t-1})$$

In the initial estimation, the coefficient on interest rates was insignificant and had the wrong sign. Wholesale price and the purchase price had coefficients of nearly equal and opposite size. The equation was re-estimated without interest rates, with the price variables as a difference (PACW - PACS), and with retail demand and exports combined in a single expression:

$$SACC = \underset{(1.83)}{71.9} + \underset{(1.99)}{4.0}(PACW-PACS) + \underset{(2.06)}{.25}(QACRD - QACRD_{t-1} + XAC - XACT_{t-1}) + \underset{(5.55)}{.69}\ SACC_{t-1}$$

$(R^2 = .66)$

The American cheese submodel is closed with an identity expressing government stocks (SACG) as the residual of all supplies less all other uses:

$$SACG = QACWS + MAC + SACC_{t-1} + SACG_{t-1} - QACRD - SACC - DAC - QACM - XAC$$

The Butter Submodel

The butter submodel has the same structure as the cheese submodel, five stochastic equations: retail demand and price, wholesale supply and price, and commercial stocks. The submodel is closed with the government stocks identity.

The estimation of retail demand for butter began with the conceptual framework: retail consumption (QBRD) as a function of retail price (PBR), price of oleomargarine (PO), consumer price index for all food (CPIAF), and income (Y). The equation was estimated in both current and real (deflated by CPI non-food) prices. However, despite the good fit of the equation and low standard errors, the sign on own-price was opposite theoretical expectations. Adding or deleting various exogenous factors and including a trend variable did not correct the sign.

The relationship between the variables was explored using the correlation among butter consumption and all exogenous variables. The matrix revealed that while the direction of the relationship between butter price and butter consumption was negative, the correlation between consumption and all other exogenous variables was also negative and the magnitude of these coefficients was at least as great as that between butter price and consumption. This is reasonable considering the steady downward trend of butter consumption (correlation with trend = -.91) and the steady upward trend of the consumer price indices and income, while retail price of butter has fluctuated around an upward trend.

Several functional forms were tested to attempt to improve the demand relationship. The next estimation was as follows:

$$QBRD = \underset{(28.53)}{2718.0} + \underset{(5.78)}{900.9}\,(PO/PBR) - \underset{(-6.54)}{825.9}\,(CPINF/PBR) - \underset{(-8.81)}{14.48}\,TIME$$

$$(R^2 = .94)$$

The positive sign on PO/PBR indicates that as the price of butter increases (decreases) relative to the price of oleo, the retail consumption of butter should decrease (increase).

The equation simulated well over the historical period. However, the ex ante (1981-90) simulation projected a decline in butter consumption of 50 percent between 1981 and 1990. The large negative coefficient on CPINF/PBR was hypothesized to be responsible for predicting such a large decline. Deleting this variable from the equation, as follows, provided a more reasonable forecast.

$$QBRD = \underset{(19.19)}{2339.9} + \underset{(1.91)}{388.8}\,PO/PBR - \underset{(-11.28)}{21.4}\,TIME$$

$$(R^2 = .85)$$

The final estimation included the square root of trend (TIMSQR) to better specify the change in butter consumption over time.

$$QBRD = \underset{(7.92)}{22370.1} + \underset{(1.25)}{148.5}\,PO/PBR + \underset{(6.60)}{274.3}\,TIME - \underset{(-7.10)}{4863.0}\,TIMSQR$$

$$(R^2 = .95)$$

Retail price of butter (PBR) is a margin equation that creates an equilibrium between the retail and wholesale markets:

$$PBR = \underset{(-2.81)}{-7.2} + \underset{(16.79)}{1.3\ PBW} + \underset{(2.03)}{2.4\ WR} + \underset{(1.69)}{3.7\ DUM7374}$$

$$(R^2 = .99)$$

Wholesale price (PBW) is a function of the purchase price for butter, (PBS). The intercept was deleted because of a high standard error. A dummy variable for 1973-74 was included to account for the large shifts in observed values for those years:

$$PBW = \underset{(178.86)}{1.0\ PBS} + \underset{(3.32)}{5.4\ DUM7374}$$

$$(R^2 = .99)$$

Wholesale production of butter (QBWS) was estimated as a function of own price (PBW), price of complement (PNDMW), and input prices (PGB, WW). Wholesale production of nonfat dry milk (QNDMWS) was also included in the estimation because it is a joint product with butter. All signs are as expected for this estimation:

$$QBWS = \underset{(6.74)}{844.2} + \underset{(3.54)}{20.5\ PBW} + \underset{(3.24)}{32.2\ PNDMW} - \underset{(-2.06)}{292.3\ PGB} - \underset{(5.06)}{323.4\ WW}$$

$$+ \underset{(4.24)}{.34\ QNDMWS}$$

The equation simulated well over the historical period, but predicted sharp increases in the ex ante period. When the model was simulated using a lower support price for butter, the large negative coefficient on the Grade B milk price caused an explosive increase in production. As the support price on milk was lowered, the Grade B price declined accordingly and butter production increased sharply until the model could not solve. Consequently, remedial measures were required. The quantity of raw milk produced (QRM) was added to this equation with the argument that butter (and nonfat dry milk) is a residual product and that the amount of butter produced is a function of the supply of raw milk available. However, the inclusion of both Grade B milk price and raw milk production caused a high degree of collinearity in the equation that resulted in a negative sign on own price:

$$QBWS = \underset{(-6.33)}{-2808.8} - \underset{(-.11)}{0.3\ PBW} + \underset{(8.75)}{0.03\ QRM} - \underset{(-2.71)}{53.4\ PGB}$$

$$(R^2 = .93)$$

Finally, a form was developed that combined these factors in a statistically sound equation:

$$QBWS = \underset{(-10.24)}{-9687.2\ PGB/PBW} + \underset{(28.02)}{.02\ QRM}$$

$$(R^2 = .85)$$

The original specification for commercial stocks of butter (SBC) as outlined in the conceptual model is:

$$SBC = g_2(PBW,\ PBS,\ QBRD,\ QBRD_{t-1},\ XB,\ XB_{t-1},\ RC,\ SBC_{t-1})$$

When estimated, this equation had a poor statistical fit ($R^2 = .06$) with t-statistics below one for all of the variables. Various functional forms were tested, including first differences of the explanatory variables. All of these specifications had high standard errors for the coefficients and R^2 values below 25%.

In an attempt to find variables that exhibited a stronger statistical relationship with commercial stocks, the correlation between commercial butter stocks and consumption and supply variables was estimated. Raw milk production (QRM), wholesale production of butter (QBWS) and commercial stocks of nonfat dry milk (SNDMC) were all highly correlated to commercial butter stocks. A new equation was estimated including these variables:

$$SBC = \underset{(-2.21)}{-122.4} - \underset{(-1.44)}{.01\ QBWS} + \underset{(2.24)}{.14\ SNDMC} + \underset{(2.47)}{.001\ QRM} - \underset{(-0.26)}{.05\ SBC_{t-1}}$$

$$(R^2 = .37)$$

This equation seemed to fit better; however, it simulated very poorly over the historical period. A new functional form was tested, using the change in stocks as the dependent variable. Several variables were added or deleted from the equation based on their standard errors, until a final specification was determined.

$$SBC-SBC_{t-1} = \underset{(-1.68)}{-88.7} \underset{(-1.40)}{-0.22}\ QBRD + \underset{(3.83)}{0.20}\ (SNDMC-SNDMC_{t-1}) + \underset{(1.90)}{.00008}\ QRM$$

$$(R^2 = .45)$$

The butter submodel is closed with a government stocks (SBG) identity:

$$SBG = QBWS + MB + SBC_{t-1} - SBG_{t-1} - QBRD - SBC - DB - QBM - XB$$

Nonfat Dry Milk Submodel

The structure of the nonfat dry milk submodel differs slightly from those for cheese and butter in that demand is estimated at the wholesale rather than retail level. Nonfat dry milk is primarily used as an input to the manufacture of cereal and bakery products, variety meats, animal feed, and other dairy products. Retail consumption of nonfat dry milk is small and data for it are unavailable.

The demand equation for nonfat dry milk is estimated as a derived demand equation at the wholesale level:

$$QNDMWD = g_1(PNDMW, PFMR, CPIF, CPINF, CPIAF, Y, WW)$$

Derived wholesale demand is expressed as a function of variables affecting the demand for final uses, (CPIF, CPINF, CPIAF, PFMR, Y) as well as variables influencing wholesale demand (PNDMW, WW).

After the initial estimation, the nonfood CPI and wholesale wage were eliminated from the equation because of high standard errors. The binary variable DUM7374 was added and proved significant.

$$QNDMWD = \underset{(3.21)}{840.1} - \underset{(-2.71)}{13.9}\,PNDMW + \underset{(1.42)}{13.1}\,PFMR + \underset{(.77)}{1.47}\,CPIF - \underset{(-1.83)}{8.9}\,CPIF + \underset{(3.72)}{.89}\,Y + \underset{(2.67)}{194.0}\,DUM7374$$

When the model was simulated over the historical period, this form for wholesale demand provided reasonable estimates. However, when the simulation period was extended beyond the range of the data, the simulated values for QNDMWD declined 70% over the period 1981-90, a problem similar to that experienced with retail consumption of butter. Based on trend, a decline in commercial use of nonfat dry milk is reasonable, but not to the degree predicted by the model. Several new specifications were estimated to try and find an equation that provided reasonable values in an ex ante simulation.

A base model, which includes only wholesale price and DUM7374 provided ex ante simulation values that increased over 100% in the ten-year period. Variables were added to this equation until a statistically sound equation was found that simulated a reasonable decrease in the commercial use of nonfat dry milk over the ex ante simulation period.

$$QNDMWD = \underset{(3.38)}{641.7} - \underset{(-4.49)}{17.4}\,PNDMW + \underset{(2.14)}{17.1}\,PFMR - \underset{(-1.89)}{6.5}\,CPIAF + \underset{(3.91)}{.81}\,Y + \underset{(4.40)}{231.9}\,DUM7374$$

$$(R^2 = .86)$$

This equation still supports the conceptual form of a derived demand equation, as well as providing reasonable simulation values.

As with the equation for the wholesale supply of butter, the wholesale production of nonfat dry milk (QACWS) was estimated as a function of own price (PNDMW), price of other dairy products (PFMW, PACW, PBW) and price of inputs (PGB, WW). Several variables were deleted (WW, PACW, PFMR) because of high standard errors. The full model was simulated using the following equation:

$$QNDMWS = \underset{(5.4)}{1359.3} + \underset{(1.06)}{33.8}\ PNDMW + \underset{(2.38)}{39.3}\ PBW - \underset{(-1.80)}{728.8}\ PGB$$

$$(R^2 = .77)$$

The large negative coefficient on Grade B milk price (PGB) resulted in the same solution problem as occurred for the wholesale supply of butter. If the support price and consequently the Grade B milk price was lowered, wholesale production increased disproportionately until the market could not clear. The quantity of raw milk produced (QRM) was added to the equation and various functional forms were estimated, but none of the equations provided an adequate fit, and all had large simulation errors over the historical period. Finally wholesale supply was estimated as a function of the production of butter alone.

$$QNDMWS = \underset{(-2.39)}{-590.2} + \underset{(8.52)}{1.67}\ QBWS$$

$$(R^2 = .75)$$

This equation is conceptually supported by the fact that butter and nonfat dry milk are joint products. Statistically, this equation simulated well over the historical period and provided reasonable values for the ex ante period 1981-90.

Wholesale price is estimated as a function of purchase price for nonfat dry milk (PNDMS) and DUM7374. The intercept was insignificant in the initial estimation. The final form is:

$$PNDMW = \underset{(268.24)}{1.0}\ PNDMS + \underset{(11.81)}{7.1}\ DUM7374$$

$$(R^2 = .99)$$

Commercial stocks for nonfat dry milk (SNDMC) were estimated based on the specification described in the conceptual model. The equation suffered from the same statistical problems as in the butter submodel, weak t-values and low R^2. Some of the same techniques used for commercial butter stocks were used to find a more appropriate specification. The correlation matrix of stocks and other endogenous variables pinpointed wholesale use of dry milk (QNDMWD), commercial stocks of butter (SBC), and purchase price (PNDMS) as having a high correlation with commercial stocks. Several functional forms were tested. A specification using first differences had the best test statistics and the most accurate ex post simulation values.

$$\underset{}{SNDMC-SNDMC_{t-1}} = \underset{(-1.06)}{-7.9} + \underset{(1.25)}{.12}\,(QNDMWD-QNDMWD_{t-1}) + \underset{(2.00)}{1.3}\,(SBC-SBC_{t-1})$$

$$+ \underset{(1.46)}{2.5}\,(PNDMS-PNDMS_{t-1})$$

$$(R^2 = .42)$$

The nonfat dry milk submodel is closed with the government stocks (SNDMG) identity:

$$SNDMG = QNDMWS + MNDM + SNDMC_{t-1} + SNDMG_{t-1} - QNDMWD - SNDMC - QNDMM$$
$$- XNDM - DNDM - AFNDM$$

Frozen Desserts Submodel

The frozen desserts submodel consists of three stochastic equations and a closing identity. There are no stocks, exports, or USDA donations of frozen desserts.

Retail consumption (QFDRD) is a function of own price (PICR), price of substitutes (CPISSP) and income (Y), all deflated by the nonfood CPI (CPINF):

$$QFDRD = \underset{(7.39)}{14715.4} - \underset{(-6.64)}{6911.7}\,PICR/CPINF + \underset{(4.42)}{2643.4}\,CPISSP/CPINF$$

$$- \underset{(-1.34)}{2281.4}\,CPIAF/CPINF + \underset{(1.20)}{124.6}\,Y/CPINF$$

$$(R^2 = .96)$$

Retail price (PICR) is a function of wholesale price (PICW) and trend. The original estimation included the retail wage rate; however, the sign was perverse, so it was eliminated.

$$\text{PICR} = \underset{(8.60)}{65.3} + \underset{(36.89)}{.61}\ \text{PICW} - \underset{(-9.71)}{1.5}\ \text{TIME}$$

$$(R^2 = .99)$$

Similarly, in the equation for wholesale price (PICW), wholesale wage was eliminated because of high standard error.

$$\text{PICW} = \underset{(39.03)}{97.6} + \underset{(61.82)}{23.9}\ \text{PGB} - \underset{(4.14)}{18.0}\ \text{DUM7374}$$

$$(R^2 = .99)$$

The frozen desserts submodel is closed with an identity for wholesale production (QFDWS):

$$\text{QFDWS} = \text{QFDRD} + \text{QFDM} + \text{MFD}$$

The Conceptual Raw Milk Submodel

The raw milk submodel consists of two sets of equations: factors that explain farmers' decisions that result in milk production and farm level prices which link this sector to the general dairy products submodel. The conceptual framework for each of these sets of equations will be discussed, and then the statistical estimation procedure will be presented.

A farmer can vary his production in two basic ways--he can change the number of cows he milks or he can alter the output per cow. Thus, in the aggregate, the quantity of raw milk produced can be explained as follows:

$$\text{QRM} = \text{NC} * \text{PPC}$$

where

QRM = the quantity of raw milk produced,

NC = the number of cows milked (observed as year-end cattle inventories),

PPC = production per cow.

Changes in the production per cow can be the result of the farmer's response to changes in output and input prices or changes in dairy breeding technology which affect the genetic potential of offspring. Therefore, production per cow is taken here as a function of the price of raw milk (PRM), the cost of dairy feed (PF), the farm wage rate (WF), and the percentage of cows artificially inseminated in year t-3 (AI_{t-3}). The technology variable, artificial insemination, is lagged three years because the benefit of artificial breeding to bulls which transmit higher production potential does not appear until the calf born of an artifically bred dam begins lactating. This occurs about three years after conception. The production per cow function is as follows:

$$PPC = h_1(PRM, PF, WF, AI_{t-3})$$

where

PRM = price of raw milk,

PF = cost of average dairy ration,

WF = farm wage rate,

AI_{t-3} = percentage of cows artificially inseminated three years ago.

The equations explaining farmers decisions as to herd size are based on the work of Jarvis (43) who uses a capital theory model to explain the supply response behavior of beef producers. According to Jarvis (43, p.506), the capital value of the dairy animal is determined by the discounted value of the future stream of income from the sale of milk produced by the animal, but the slaughter price of beef determines the salvage value of the dairy animal. In order to reflect investment decisions, it is necessary to include stock relationships for different age groups of cattle. Different age groups must also be recognized since the effect of price changes is not uniform between age groups. A change in the price of milk relative to the cost of inputs will have a greater impact on the capital value of the animal having the longer discounting horizon. In other words, a change in the expected milk price will have a greater effect on the capital value of a younger animal, than on that of an older animal.

The model, therefore, includes equations estimating the number of dairy cows (NC) and the number of dairy heifers (NH). These two are regressed on the same set of factors:

$$NC, NH = h_{2,3}(PRM, PBF, PF, NC_{t-1}, NH_{t-1})$$

where

PRM = price of raw milk,

PBF = price of culled dairy animals (a salvage price),

PF = price of dairy feed ration.

Other factors are represented in the model indirectly. Births are hypothesized to be a fairly constant proportion of the population, and are therefore some function of lagged herd numbers. Cattle are eliminated from the herd by deaths and culling. Data on culling rates and number of deaths are not available. Culling is to some extent a regular disinvestment decision for the dairy farmer in which a fairly constant proportion of each age group is culled per year. It is also hypothesized that the culling rate varies with the prices for milk, and feed. (See Novakovic (56) for a more detailed presentation of the herd dynamics.)

The three stochastic equations, production per cow, number of cows and number of heifers, along with the identity for the quantity of raw milk make up the set of equations representing the farmer's decision-making process.

The production of raw milk (QRM) is linked to the other general dairy product sectors through the price equation for raw milk (PRM) and manufacturing grade milk (PCB). The price received by farmers (PRM) is patterned after the blend price formula used in federal milk marketing orders:

$$PRM = h_4[(PI*QFMWS + PGB(QRM-QFMWS))/QRM]$$

where

PI = Class I milk price

QFMWS = wholesale production of fluid milk (Class I) products

PGB = price of manufacturing grade milk.

The production of raw milk is then linked to the markets for manufactured products by the price of Grade B milk (PGB). This price is expressed as a function of the prices manufacturers receive for their products (PACW, PBW, PNDMW), the input costs they face (ZW), and the quantity of milk available for processing. The Grade B milk price is also determined by the residual supply of Grade A milk, i.e., milk not used in fluid consumption. The specification of the equation for Grade B milk price is:

$$PGB = h_5(PiW, ZW, QRM-QFMWS-QFDWS)$$

where

i = cheese, butter, nonfat dry milk,

PiW = wholesale prices of i^{th} manufactured product,

ZW = vector of input costs,

QRM-QFMWS-QFDWS = Grade A milk available for manufacturing.

To summarize the formulation of the raw milk sector, the statistical forms for the equations are as follows:

$$QRM = NC*PPC$$

$$PPC = h_1(PRM, PF, WF, AI_{t-3})$$

$$NC = h_2(PRM, PBF, PF, NC_{t-1}, NH_{t-1})$$

$$NH = h_3(PRM, PBF, PF, NC_{t-1}, NH_{t-1})$$

$$PRM = h_4\left[\frac{PI*QFMWS+PGB(QRM-QFMWS)}{QRM}\right]$$

$$PGB = h_5(PACW, PBW, PNDMW, WW, (QRM-QFMWS-QFDWS))$$

The estimation procedure for each of these equations shall now be discussed in turn.

Specification and Estimation of the Raw Milk Submodel

The equation for production per cow fit well in its conceptual form. Farm wage (WF) was deleted because of a high standard error.

$$PPC = \underset{(25.86)}{3546.6} + \underset{(4.70)}{245.6}\ PRM - \underset{(-2.90)}{243.4}\ PF + \underset{(25.15)}{114.4}\ AI_{t-3}$$

$$(R^2 = .99)$$

Obtaining a good statistical fit on the equations for herd size was more problematic. Estimation of the conceptual form of these equations resulted in high standard errors and apparent multicollinearity:

$$NC = \underset{(1.03)}{716.8} + \underset{(.22)}{25.1}\ PRM - \underset{(-.88)}{126.8}\ PF \underset{(-.19)}{-2.2}\ PBF + \underset{(2.87)}{.61}\ NC_{t-1} + \underset{(1.69)}{1.1}\ NH_{t-1}$$

$$NH = \underset{(-.19)}{-56.2} + \underset{(.55)}{33.3}\ PF + \underset{(2.42)}{11.9}\ BF - \underset{(-.63)}{28.9}\ PRM - \underset{(-.20)}{.02}\ NC_{t-1} + \underset{(3.89)}{1.0}\ NH_{t-1}$$

With an R^2 value of .99 and low t-values on coefficients for both these estimations it is clear that multicollinearity is a problem and that lagged herd numbers are explaining the major portion of the variation.

A new formulation was estimated that specified feed and beef prices relative to the price of raw milk (PF/PRM and PBF/PRM). The lagged herd variables were combined into a single variable. Production per cow was included in the equation to test the hypothesis that increases in efficiency cause decreases in input (cows) usage. For number of cows the resulting estimation is as follows:

$$NC = \underset{(1.81)}{3351.5} - \underset{(-.57)}{44.0}\ PBF/PRM - \underset{(-1.11)}{945.1}\ PF/PRM - \underset{(-1.68)}{0.2}\ PPC + \underset{(17.87)}{.67}\ (NC_{t-1} + NH_{t-1})$$

$$(R^2 = .997)$$

Again, multicollinearity is a problem and lagged herd numbers are explaining the major portion of the variation. Similar problems were encountered in the estimation of heifer numbers.

These problems led to a reconsideration of the conceptual formulation of these equations. It was hypothesized that farmers' decision on herd size could be modeled as an asymmetric response to changes in the prices of inputs (PF), alternative uses (PBF), and output (PRM). In other words, the farmer would respond differently to an increase in relative price than to a decrease.

Several formulations of the asymmetric response were considered to model the farmers' decision-making process. The chosen form is based on the work of Houck (40) and Wolfram (74). For this form the price ratios PF/PRM and PBF/PRM are each segmented into two separate variables, for example for PF/PRM:

PF/PRM^{+} = cumulative sum of the positive first differences

PF/PRM^{-} = cumulative sum of the negative first differences.

The up variable (+) will always be positive and the down variable (-) is always negative. By definition, when PF/PRM^{+} increases from t-1 to t (first difference is positive), PF/PRM^{-} remains constant. This formulation of asymmetric variables is preferable to a simple binary variable approach (i.e., 0 if no increase, 1 if increase) because it takes into account the cumulative aspect of the change. This form allows that the response may be different if there are t+i periods of increase or decrease in price.

This specification was estimated for number of cows including production per cow and farm wage:

$$NC = \underset{(3.26)}{10741.6} - \underset{(-3.08)}{4693.2}\ PF/PRM^{+} + \underset{(2.38)}{5155.7}\ PF/PRM^{-}$$

$$- \underset{(-2.05)}{214.0}\ PBF/PRM^{+} + \underset{(.33)}{36.9}\ PBF/PRM^{-} - \underset{(-2.78)}{.65}\ PPC$$

$$+ \underset{(5.66)}{.45}\ (NC_{t-1} + NH_{t-1}) + \underset{(3.39)}{21.8}\ WF$$

$$(R^2 = .99)$$

Similarly for NH

$$NH = \underset{(-.52)}{992.2} - \underset{(2.44)}{2286.4}\ PF/PRM^{+} - \underset{(-2.13)}{2118.1}\ PF/PRM^{-}$$

$$- \underset{(.65)}{44.8}\ PBF/PRM^{+} + \underset{(1.10)}{90.9}\ PBF/PRM^{-} - \underset{(-.14)}{.02}\ PPC$$

$$+ \underset{(7.38)}{.27}\ (NC_{t-1} + NH_{t-1})$$

$$(R^2 = .99)$$

For consistency PPC was also reestimated with the asymmetric form.

$$PPC = \underset{(26.20)}{4048.8} - \underset{(-0.80)}{469.0}\ PF/PRM^{+} - \underset{(-7.59)}{4490.5}\ PF/PRM^{-} + \underset{(16.33)}{93.5}\ AI_{t-3}$$

The results were not encouraging for the herd size equations. The approximately equal but opposite signed coefficients for both PF/PRM variables indicate that there may not be a significant asymmetric response. Similarly for PBF/PRM in the cows equation. In the heifer equation the beef price ratios were not significant.

The equation for production per cow, however, exhibited a significantly different response to price increases than decreases. This equation was therefore included in the final model.

New formulations for herd size were developed and estimated using lagged price ratios and linear price. The best fit for heifer numbers was achieved using lagged linear prices for feed and raw milk.

$$NH = \underset{(1.03)}{1522.0} + \underset{(5.27)}{192.1}\ PRM - \underset{(-1.79)}{80.6}\ PF_{t-1}$$

$$+ \underset{(5.97)}{.19}\ (NC_{t-1} + NH_{t-1}) - \underset{(-1.56)}{.17}\ PPC$$

$$(R^2 = .99)$$

For number of cows the price ratio specification provided the best results:

$$NC = \underset{(1.72)}{3435.4} - \underset{(-.63)}{797.5}\ PF/PRM - \underset{(-.91)}{1433.0}\ (PF/PRM)_{t-1} - \underset{(-2.09)}{204.8}\ (PBF/PRM)$$

$$+ \underset{(1.54)}{143.7}\ (PBF/PRM)_{t-1} - \underset{(-1.39)}{.13}\ PPC + \underset{(19.02)}{.70}\ (NC_{t-1} + NH_{t-1})$$

$$(R^2 = .998)$$

Using these final forms, the model was simulated over the historical period and provided reasonable values. However, when the model's stability was tested by a 30-year ex ante simulation (holding all exogenous variables constant at 1981 levels), the formulation for cow numbers revealed a structural problem. The simulation revealed that the coefficient on lagged herd numbers introduced an explosive element that caused herd numbers to continue to increase in spite of all exogenous effects being held constant. The projections did not converge. This problem required another fresh look at the equation for the number of cows.

A specification was required for cows that included the lagged effects and yet did not cause explosive changes in the dependent variable. In the current specification of lagged herd numbers, $NC_{t-1} + NH_{t-1}$ represent a Koyck transformation of a distributed lag function, where the lag is distributed over an infinite period. Given the explosive element contained in this lag structure, a more reasonable approach may be to specifically limit the lag. A three period lag was chosen to reflect the biological lag in breeding a new generation of dairy cows and is consistent with the findings of other supply studies (c.f. Elterich _et al_.) Limiting the lag structure to three periods assumes that herd numbers in periods t-4 to infinity have no effect on current herd numbers.

This lag structure was estimated using both linear prices and price ratios. Multicollinearity was a severe problem in the equation using linear prices and despite an R^2 value of .96, no variables except production per cow had a t-value greater than one. The equation was respecified with lagged exogenous variables expressed as first differences:

$$\begin{aligned} NC = {} & \underset{(34.82)}{33595.8} - \underset{(-.14)}{46.8}\,(PRM - PRM_{t-1}) + \underset{(4.44)}{1888.5}\,(PRM_{t-1} - PRM_{t-2}) \\ & - \underset{(-4.44)}{1606.2}\,(PF_{t-1} - PF_{t-2}) - \underset{(-20.94)}{2.12}\,PPC \\ & + \underset{(3.77)}{1.35}\,((NC_{t-2} + NH_{t-2}) - (NC_{t-3} + NH_{t-3})) \end{aligned}$$

This specification was utilized in a simulation for the historical period and an ex ante simulation to 1990. Over the ex post period the simulated values were quite accurate; however, beyond 1980 the simulated values decreased by an increasing percentage each year. When compared to actual data for 1981-82, the equation severely underestimated the actual values.

New estimations were made on equations combining functional forms of lags and price ratios. Herd numbers were lagged two periods instead of one as in previous estimations. Finally, an equation was estimated that simulated well and had a good statistical fit.

$$\begin{aligned} NC = {} & \underset{(1.55)}{5020.1} - \underset{(-2.02)}{3628.5}\,(PF/PRM)_{t-1} - \underset{(-1.99)}{323.6}\,PBF/PRM \\ & - \underset{(-.63)}{0.1}\,PPC + \underset{(12.09)}{0.68}\,(NC_{t-2} + NH_{t-2}) \\ & (R^2 = .99) \end{aligned}$$

The final two equations in the raw milk submodel are the price equations for raw milk and Grade B milk. The raw milk price equation is nearly an identity. One would not expect it conceptually or empirically to be an exact identity because not all milk is priced in the fashion presumed by the equation, but it should be quite close. Hence the following equation was estimated:

$$PRM = \underset{(1.96)}{.066} + \underset{(213.87)}{1.01} \; \frac{PI * QFMWS + PGB * (QRM-QFMWS)}{QRM}$$

$$(R^2 = .999)$$

As the coefficients indicate, this is a near identity; the predictions are improved by the slight adjustments in the intercept and multiplicand.

The original estimation of PGB is as follows:

$$PGB = \underset{(-.8)}{-\ .1} + \underset{(6.19)}{.03\ PACW} + \underset{(9.44)}{.02\ PBM} + \underset{(10.81)}{.05\ PNDMW}$$

$$\underset{(-.75)}{-\ .06\ WW} + \underset{(.68)}{.00005\ (QRM-QFMWS-QFDWS)}$$

$$(R^2 = .999)$$

The wholesale wage (WW), the quantity of milk available for manufacturing purposes (QRM-QFMWS-QFDWS), and the intercept were deleted to achieve the final form.

$$PGB = \underset{(6.89)}{.03\ PACW} + \underset{(13.16)}{.02\ PBW} + \underset{(12.96)}{.05\ PNDMW}$$

$$(R^2 = .999)$$

The Performance Variables Submodel

The Conceptual Framework

The final submodel contains 10 equations measuring certain performance variables and the level of government intervention through purchases of dairy products. Two equations in this submodel also serve to close the entire model by linking estimated production to utilization.

This submodel augments the policy analysis capabilities of the model. As shall be demonstrated later, the model is adaptable to various policy scenarios. By simulating the model under various policy assumptions, comparison of the estimated values of the factors in this submodel are the important gauge of the impact of the policies.

The nine endogenous variables estimated in this submodel are:

NRAC: CCC net removals of American cheese

NRB: CCC net removals of butter

NRNDM: CCC net removals of nonfat dry milk

SMEC: ending commercial stocks of dairy products; milk equivalent

CE: consumer expenditure on dairy products

GPI: gross producer income

CDME: commercial disappearance of dairy products; milk equivalent

NRME: CCC net removals of dairy products; milk equivalent

NGP: net CCC purchases; total dollar value

The equations for CCC purchases express net removals of each dairy product as a function of the change in government stocks, and the transfer of dairy products from stocks into other uses:

$$NRi = k_i(SGi_t - SGi_{t-1}, Di, Xi)$$

where

NRi = net removals of American cheese (NRAC), butter (NRB), and nonfat dry milk (NRNDM)

Di = USDA donations of the i^{th} product

Xi = exports of the i^{th} product.

The milk equivalent value for commercial stocks (SMEC) is expressed as a function of the component dairy products which are included in the model:

$$SMEC = k_4 \text{ (SACC, SBC, SNDMC)}$$

where

SiC = commercial stocks of American cheese, butter and nonfat dry milk.

Equations for consumer expenditures (CE) and gross producer income (GPI) are included in the model as macro level performance indicators.

$$CE = k_5(\sum_i PiR * QiRD)$$

where

PiR = retail price of fluid milk, ice cream, cheese and butter,

QiRD = retail consumption of the respective products.

Gross producer income is estimated as a function of the product of the price of raw milk (PRM) and the quantity produced (QRM).

$$GPI = k_6(QRM * PRM)$$

Besides being important for policy analysis, the next two equations in the model, commercial disappearance (CDME) and net removals (NRME), also serve to close the model by linking supply and utilization.

In the original specification (Novakovic and Thompson), the model was closed with an identity equating quantity of raw milk with the sum of the production of dairy products estimated in the model and the (milk equivalent) quantity of other dairy products or QO:

$$QRM = QFMWS + 8.703\ QACWS + 21.702\ QBWS + 0.216\ QNDMWS + QFDWS + QO$$

Expressing the quantity of dairy products in milk equivalent terms and moving QO to the left-hand size, the identity included in the model was therefore:

$$QO = QRM - QFMWS - 8.703\ QACWS - 21.702\ QBWS - 0.216\ QNDMWS - QFDWS$$

This identity proved to be unsatisfactory as a model closing equation. While it provided reasonable values for the historical period, the values for QO increased to unrealistic levels when the model was simulated beyond 1981. Any increase in the production of raw milk that was not processed into products for which a demand was specified ended up in QO.

This formulation is replaced with the two equations for CDME and NRME. The equation for commercial disappearance includes the utilizations of dairy products not accounted for in net removals:

$$CDME = k_7(\sum_i QiRD + QiM)$$

where

i = fluid milk, American cheese, butter, nonfat dry milk, frozen desserts,

QiRD = retail demand for the i^{th} product,

QiM = military use of the i^{th} product.

The equation for milk equivalent net removals (NRME) closes the model by defining net removals as the residual of supply and utilization:

$$NRME = QRM + SMEC_{t-1} + MME - CDME - SMEC_t$$

where

MME = the milk equivalent of all imports.[5/]

These equations have two main advantages over the previous specification. First and foremost, unlike QO, CDME and NRME are based on real data. These variables can therefore serve the purpose as performance variables in determining the model's predictive ability. Secondly, the use of actual values allows for the stochastic estimation of CDME. Because the model doesn't estimate equations for all dairy products the equating of production and utilization as estimated in the model is not truly an identity.

[5/] MME is calculated from the following relationship:

$$MME = -3.33 + .01\ MAC + .04\ MB + .07\ TIME$$
$$(R^2 = .84)$$

The equation for net government purchases (NGP) is an accounting identity that provides a total dollar value for government purchases:

NGP = NRME * PS

where

PS = the milk equivalent value of CCC purchase prices.

Specification and Estimation

To summarize this submodel, the following are the forms of the equations as originally estimated:

$$NRAC = a_0 + a_1 \ (SACG_t - SACG_{t-1} + DAC + XAC)$$

$$NRB = b_0 + b_1 \ (SBG_t - SBG_{t-1} + DB + XB)$$

$$NRNDM = c_0 + c_1 \ (SNDMG_t - SNDMG_{t-1} + DNDM + XNDM)$$

$$SMEC = d_0 + d_1 \ SACC + d_2 \ SBC + d_3 \ SNDMC$$

$$GPI = e_0 + e_1 \ (PRM * QRM)$$

$$CE = f_0 + f_1 \ (PFMR * QFMRD + PICR * QFDRD + PACR * QACRD + PBR * QBRD)$$

$$CDME = g_0 + g_1 \ (QFMRD+DFM) + g_2 \ (QACRD+QACM) + g_3 \ (QBRD+QBM) + g_4 \ (AFNDM+QNDMM+QNDMWD) + g_5 \ (QFDRD)$$

$$NRME = QRM + SMEC_{t-1} + MME - CDME - SMEC$$

$$NGP = NRME * PS$$

The estimated equations went through few changes before a final form was achieved. The intercept was deleted from the equations for NRB and NRNDM because it was not significantly different from zero, and CDME was slightly revised.

The final forms of the estimated equations are:

$$NRAC = \underset{(-3.65)}{-\ 38.6} + \underset{(18.19)}{1.25} \ (SACG - SACG_{t-1} + DAC + XAC)$$

$$(R^2 = .93)$$

$$NRB = \underset{(50.32)}{1.1}\ (SBG - SBG_{t-1} + DB + XB)$$

$(R^2 = .95)$

$$NRNDM = \underset{(54.62)}{1.1}\ (SNDMG - SNDMG_{t-1} + DNDM + XNDM)$$

$(R^2 = .96)$

$$SMEC = 0.76 + .009\ SACC + .021\ SBC + .003\ SNDMC$$

$(R^2 = .96)$

$$CE = \underset{(-14.83)}{-\ 5916} + \underset{(62.39)}{.02}\ (PFMR*QFMRD/4.3 + PICR*QFDRD/6$$

$$+ PACR*QACRD/2 + PBR*QBRD)$$

$(R^2 = .99)$

$$GPI = \underset{(-8.13)}{-\ .48} + \underset{(155.70)}{.00001}\ (PRM*QRM)$$

The original estimation of CDME is as follows:

$$CDME = \underset{(-1.43)}{-\ 18691.7} + \underset{(6.47)}{1.48}\ (QFMRD+DFM)$$

$$+ \underset{(11.96)}{20.47}\ (QACRD+QACM) + \underset{(6.87)}{22.57}\ (QBRD+QBM)$$

$$\underset{(-0.08)}{-\ 0.25}\ (QNDMWD+AFNDM+QNDMM)$$

$(R^2 = .91)$

The equation was re-estimated with a separate coefficient on each variable. None of the military consumption variables proved significant, nor did demand for nonfat dry milk. The final form for this equation is therefore:

$$CDME = \underset{(-3.80)}{-\ 44749.3} + \underset{(9.82)}{1.54}\ QFMRD + \underset{(14.08)}{17.03}\ QACRD$$

$$+ \underset{(12.27)}{27.96}\ QBRD + \underset{(5.58)}{2.6}\ QFDRD$$

$(R^2 = .95)$

Ex Post Validation of the Model

There are a variety of statistical methods for testing the quality of an econometric model. Generally all are designed as measures of the predictive accuracy of the simulated values when compared with the actual. Two measures will be used to assess the quality of the current model: the root mean square percent error (RMSPE) and turning point error (TPE).

The root mean square error standardizes the positive and negative errors in prediction in order to assess the overall degree of error. The RMSE is calculated as:

$$RMSE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} (F_t - A_t)^2}$$

where

F_t = forecast or simulated values

A_t = actual values.

A variation on this statistic is the root mean square percent error (RMSPE). This measure presents the error as a percentage of the actual value and provides a better method for comparison among variables of different magnitudes. This statistic is calculated as:

$$RMSPE = \sqrt{\frac{1}{T} \sum_{t=1}^{T} [(F_t - A_t)/A_t]^2}$$

The results of the ex post validation for each variable are presented in Appendix 2. Table 1 presents the endogenous variables grouped by the level of

Table 1. Variable Estimate Performance as Measured by Root Mean Square Percent Error (RMSPE).

RMSPE $\leq$ 2	
CDME:	commercial disappearance of all dairy products
PI:	Class I milk price
PPC:	production per cow
PRM:	farm price of all milk
QFMRD:	retail consumption of fluid milk products
QFMWS:	wholesale production of fluid milk products
2 < RMSPE $\leq$ 5	
CE:	consumer expenditures
GPI:	gross producer income
NC:	number of cows
NH:	number of heifers
PACW:	wholesale price of cheese
PBR:	retail price of butter
PBW:	wholesale price of butter
PFMR:	retail price of fluid milk
PGB:	farm price of Grade B milk
PICR:	retail price of ice cream
PICW:	wholesale price of ice cream
PNDMW:	wholesale price of nonfat dry milk
QBRD:	retail consumption of butter
QFDRD:	retail consumption of frozen desserts
QRM:	production of raw milk
5 < RMSPE $\leq$ 10	
PACR:	retail price of cheese
QACRD:	retail consumption of cheese
QACWS:	wholesale production of cheese
QBWS:	wholesale production of butter
QFDWS:	wholesale production of frozen desserts
QNDMWD:	wholesale consumption of nonfat dry milk
10 < RMSPE $\leq$ 20	
QNDMWS:	wholesale production of nonfat dry milk
SACC,SMEC:	ending commercial stocks of American cheese and the milk equivalent of all products, respectively
50 < RMSPE $\leq$ 100	
NGP:	net government expenditures
SBC,SNDMC:	ending commercial stocks of butter and nonfat dry milk, respectively
100 < RMSPE $\leq$ 300	
NRB,NRME,NRNDM:	net removals of butter, all products, and nonfat dry milk, respectively
RMSPE > 1000	
NRAC:	net removals of American cheese
SACG,SBC,SNDMG:	ending government stocks of American cheese, butter, and nonfat dry milk, respectively

RMSPE. Of the 40 endogenous variables, 21 have an RMSPE of less than 5%. This means that on average the simulated values differ less than 5% (+ or -) from the actual. Six more variables have a value less than 10%. The highest RMSPE are exhibited by variables that are estimated as a residual (net removals and government stocks in particular). All of the stock variables have an RMSPE greater than 50%, except for commercial stocks of cheese. This is not surprising considering the volatile nature of commercial stocks, and the low R^2 values for the equations.

The other technique used to validate the model is turning point analysis. This technique measures the ability of the model to predict changes in direction of the time path of a variable. Two types of error can occur. The model may fail to predict a turning point that actually occurs, or conversely, the simulated value may exhibit a turning point that does not occur in the actual values.

Table 2 summarizes the turning point analysis for endogenous variables. The variables are grouped by number of turning point errors out of the 24 total possible turning points from 1958-1982. This validation presents similar results as were found with RMSPE. Retail and wholesale prices, production per cow, consumer expenditures, and gross producer income have few turning point errors. This is not surprising considering these variables trended upward over the time series, with almost no change in direction. The variables exhibiting the highest number of turning point errors were again predominately the stock variables and net removals.

Overall the model simulated reasonably well. The model predicted important variables with reasonable accuracy. Both herd number variables (NC, NH) had low RMSPE, as did production per cow (PPC). The simulation of quantity of raw milk produced (QRM) had an RMSPE of only 2.4 percent and had five turning point

Table 2. Variable Estimate Performance as Measured by Turning Point Errors (TPE).

TPE = 1	
PGB:	farm price of Grade B milk
TPE = 2	
PACW:	wholesale price of cheese
PPC:	production per cow
TPE = 3	
PBW:	wholesale price of butter
PI:	Class I milk price
PICR:	retail price of ice cream
PNDMW:	wholesale price of nonfat dry milk
PRM:	farm price of all milk
TPE = 4	
CE:	consumer expenditures
GPI:	gross producer income
PBR:	retail price of butter
TPE = 5	
PFMR:	retail price of fluid milk
PICW:	wholesale price of ice cream
QFMWS:	wholesale production of fluid milk products
QNDMWD:	wholesale consumption of nonfat dry milk
CDME:	commercial disappearance of all dairy products
QRM:	production of raw milk
TPE = 6	
NC:	number of cows
NH:	number of heifers
NRNDM:	net removals of nonfat dry milk
PACW:	wholesale price of cheese
QACRD:	retail consumption of cheese
QACWS:	wholesale production of cheese
TPE = 7	
NGP:	net government expenditures
NRAC:	net removals of American cheese
QFDRD:	retail consumption of frozen desserts
QFMWS:	wholesale production of fluid milk products
QNDMWD:	wholesale consumption of nonfat dry milk
TPE = 8	
NRB:	net removals of butter
NRME:	net removals of milk equivalent of all products
QBRD:	retail consumption of butter
QFMRD:	retail consumption of fluid milk products
SBC:	ending commercial stocks of butter

Table 2. (continued).

TPE = 9
- QBWS: wholesale production of butter
- SACC: ending commercial stocks of American cheese
- SMEC: ending commercial stocks of milk equivalent of all products

TPE = 10
- SBG: ending government stocks of butter

TPE = 11
- SNDMC: ending commercial stocks of nonfat dry milk
- SNDMG: ending government stocks of nonfat dry milk

TPE = 13
- SACG: ending government stocks of American cheese

errors. The estimates of the commercial disappearance of all products (CDME) had a RMSPE of 1.7% and had five turning point errors. The average price of all milk had a RMSPE of 1.9% and had three turning point errors. Overall, the most extreme errors were exhibited for government stocks, net government purchases, and net removals. Considering that these variables are estimated as residuals, it is not surprising that their values would exhibit the effects of the cumulative error of their components.

The Simulation Model

After the final form of the model was estimated and test simulations were run on the TROLL program, the estimated equations and data sets were transferred to an IBM-PC microcomputer and integrated into a simulation program written in FORTRAN. This permitted greater flexibility to incorporate mechanisms to simulate policy changes (and is much less expensive than running TROLL on the mainframe IBM).

The solution procedure used in the program is a Gauss-Seidel technique. This is an iterative procedure for approximating the solution of a system of G equations in G unknowns. The normalized structural model is written as follows:

$$y_1 = f_1(y_2, y_3, \ldots, y_G, x_1, x_2, \ldots, x_k)$$
$$y_2 = f_2(y_1, y_2, \ldots, y_G, x_1, x_2, \ldots, x_k)$$
$$y_G = f_G(y_1, y_2, \ldots, y_{G-1}, x_1, x_2, \ldots, x_k)$$

This system is solved by making successively better guesses as to the values of y_j, where j=1, ..., G. The actual values of the endogenous variables are often used as initial guesses. Denoting the initial guesses as y_j^0 and the resulting first round calculations of the endogenous variables as y_j^1, the first round of computation using the Gauss-Seidel procedure can be written as follows:

$$y_1^1 = f_1(y_2^0, y_3^0, \ldots, y_G^0, x_1, x_2, \ldots, x_k)$$
$$y_2^1 = f_2(y_1^1, y_3^0, \ldots, y_G^0, x_1, x_2, \ldots, x_k)$$
$$\vdots$$
$$y_G^1 = f_G(y_1^1, y_2^1, \ldots, y_{G-1}^1, x_1, x_2, \ldots, x_k)$$

Substituting the most current computed value of y_j^i in each successive equation, the iteration continues until the solution converges to some desired tolerance level (delta), i.e., until

$$-\delta \leq y_j^i - y_j^{i-1} \leq \delta \qquad \text{for all } j$$

The tolerance level specified in this application is 0.01. Alternatively stricter or less strict tolerances were examined. This level was judged to be efficient and sufficiently precise.6/

The simulation thus derived was compared to the simulation procedure available on TROLL, which uses the Newton Method.7/ The simulation results for the model using these two methods differ by less than one tenth of a percent.

Two versions of the model were created for the IBM-PC. The H or historical version simulates the model over the ex post period, 1958-81. Errors and percent errors as well as actual and predicted values are printed for each endogenous variable.

The policy analysis version of the model simulates for the period 1982-90 and could be adapted to simulate for any starting point for which data are available and for any ending point to which one is willing to project exogenous variables. This version has built in mechanisms for changing support price and

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6/ See Heien (38) et al. for further details on the Gauss-Seidel procedure.

7/ See TROLL Users Guide, 2nd Edition, 1980, pp.12-2 to 12-5 for a description of this simulation method.

make allowances for manufactured products and will calculate purchase prices for cheese, butter and nonfat dry milk given this information. This version also contains several policy adjustment variables that can simulate the affect of a variety of policy scenarios. Each of these mechanisms will be discussed in turn. In addition, the model automatically calculates equilibrium prices if purchase prices are set below market clearing levels.

The primary mechanism of support policy analysis is the model's ability to calculate purchase prices for supported products based on the support price for manufacturing grade milk and CCC make allowances specified by the user. These prices are calculated as follows:

$$PACS = (PGBS + MAAC - VW) \div YAC$$

$$PBS = ((PGBS + MABNDM) * BS) \div YB$$

$$PNDMS = (PGBS + MABNDM)(1-BS) \div YNDM$$

where

MAAC, MABNDM = make allowances for American cheese, and butter/nonfat dry milk.

PGBS = target support price for milk.

VW = value of whey, specified by the calculation

$$VW = .02686 + .232 * PBS$$

BS = butter's share of the make allowance--MABNDM. This is an approximation of the USDA method for separating the cost of the joint products into the butter component and the nonfat dry milk component.

YAC, YB, YNDM = yield factors for converting pounds of raw milk into pounds of manufactured products.

If the user chooses not to specify support prices or make allowances, default values for purchase prices are used.

Another policy analysis mechanism of the model involves four exogenous variables that are included in equations to simulate various policies. These four variables are:

PROMO: this variable is included in all retail demand equations in order to simulate the impact of promotional programs on consumption of dairy products. This variable is additive; decisions about the size of a shift in consumption due to promotional activities are based on assumption and not statistical relationship.

FEE: this variable is included in the equations for gross producer income (GPI) and net government purchases (NGP). This provides an accounting of the total impact of a direct producer assessment (such as the 50¢ per hundredweight assessment under the Dairy Production Stabilization Act of 1983.)

DIVERT: this variable is used to reflect policies designed to reduce the number of dairy cows on farms and thereby the quantity of milk produced (such as the Milk Diversion Program under the DPSA of 1983). DIVERT enters the model through the number of cows equations as a simple subtraction from the predicted number of cows.

BIO: this variable is included to model the impact of bovine growth hormone or other new technologies which increase production per cow. The variable is multiplied by the intercept in the PPC equation and thereby shifts the relationship.

The values for these variables are specified by the user to conform to various assumed policy scenarios.

Beyond these specific variables, any exogenous variable can be readily changed for the purpose of policy or other economic impact analyses. In the next section of the paper, a sample run is presented to exemplify the basic characteristics of the model.

Sample Ex Ante Projections

Extrapolation of Exogenous Variables

Simulation of the model in the ex ante period requires extrapolation of the exogenous variables beyond the historical data period (1958-1982). To make reasonable extrapolations, all variables were plotted against trend for the historical period. These plots revealed two sets of variables: (1) those exhibiting a relatively linear growth rate over time and (2) those that fluctuated over time. For these two groups, two extrapolation techniques were utilized.

The group with linear growth consisted of wages, prices (PF, PBF, PO) and price indices (CPIF, CPINF, CPIAF, CPIMPF, CPISSP). Of these variables CPINF and CPIAF were identified as basic variables whose growth trends were independent and might be used to predict the growth trend of other variables. These basic variables were extrapolated to 1990 based on an annual growth rate of 6%.

Using these extrapolated values, regressions were run with CPIAF and CPINF as the exogenous variables in determining the others:

$$\text{WW, WR} = f_i(\text{CPINF})$$

$$\text{CPIF, PO, CPIMPF, CPISSP} = g_i(\text{CPIAF})$$

With the coefficients from these regressions, values for the dependent variables were generated to 1990.

Although there was some trend in feed and cull cow prices (PF and PBF), these variables were arbitrarily extended in the following fashion. Feed costs were increased three percent per year from 1983 to 1986 and decreased one percent per year thereafter. Cull cow prices were increased one percent per year from 1983 to 1987 and thereafter decreased two percent per year. The only purpose of this was to demonstrate how this kind of irregular price change impacts on the farm supply of milk.

The remaining group of exogenous variables showed no consistent pattern or long-run trend. These variables included donations, imports, exports, military use and the utilization of nonfat dry milk in animal feed. The extrapolation of these variables were based on judgments of how these values might change.

For some of these variables, a trend was visible for the past few years (1975-1982 for example). In these cases a slope was calculated based on the high and low values of this trend. The values up to 1990 were then extrapolated using these slopes. This method was used for donations of butter and cheese, and animal feed uses of nonfat dry milk.

The remainder of variables in this group have remained at a fairly constant level for the tail end of the historical period (1975-1982 roughly). Given no expectations for a change in these values, the data were extended to 1990 using the average over these years. Imports and exports were extrapolated in this manner, as was military use, and donations of nonfat milk.

Sample Projections

To demonstrate the capabilities and characteristics of the model for forecasting, a sample run is presented based on the extrapolations of exogenous variables discussed above. The results shown are for a scenario which would have decreased support prices by 75 cents per hundredweight every year beginning on January 1, 1983 and through 1985, at which time the support price would be $10.85. In 1986 and thereafter, support prices are calculated to result in net removals equal to approximately 1.5 to 2 billion pounds (compared to 16.8 billion pounds actually purchased in 1983). Results for selected variables are highlighted in Table 3. Tables 4 through 11 list the model forecasts for all endogenous variables, as well as the exogenous variable projections.

By virtue of the construction of this scenario, prices drop gradually until 1985, when the average farm price of milk bottoms out at $11.88 per hundredweight. By 1989, the farm price returns to about the 1982 level. The milk/feed price ratio reported in Table 3 indicates that although the milk price does not increase over this nine-year period, it stays in line with the assumed level feed costs once the surplus is reduced and prices begin to strengthen. Milk production drops to about 136 billion pounds by 1986 after peaking in 1983. In 1989 and 1990 production is projected to exceed the high levels set in 1983 and 1984. The 5.3% increase in milk production from 1982 to 1990 is achieved entirely by an 8.9% increase in production per cow, while cow numbers decrease 3.3% over this period. Commercial disappearance of all milk products is projected to respond strongly to the decrease in dairy prices relative to other prices and incomes. The projected 16% increase seems a bit optimistic; most industry analysts view demand to be very price inelastic. The increases in total disappearance is due entirely to increased commercial use of manufactured products. The fluid product share of commercial sales decreases from 39% in 1982 to 33% in 1990. Federal net removals and purchase costs drop to manageable levels by 1985 and are held to very low levels, by historical standards, thereafter. If commercial disappearance is biased upward, these net removal figures would be biased downward by the same magnitude.

Table 3. Selected Results for a Sample Forecast.[a/]

Year	PRM	PRM/PF	QRM	CDME	QFMRD as % of CDME	NRME	NGP
	($/cwt.)	--------(bil. lbs.)------			(%)	(bil. lbs.)	(mil. dols.)
1982	13.95	1.85	135.5	121.4	38.9	14.1	1990
1983	13.24	1.71	140.3	125.2	37.8	15.0	2011
1984	12.56	1.57	140.2	129.3	36.8	10.8	1372
1985	11.88	1.45	139.5	133.5	35.8	6.0	717
1986	12.26	1.45	136.2	135.0	35.2	1.2	153
1987	13.20	1.57	136.5	135.1	34.8	1.5	194
1988	13.56	1.63	138.5	136.9	34.0	1.6	224
1989	13.84	1.68	140.7	138.8	33.3	2.0	276
1990	13.83	1.70	142.7	141.3	32.6	1.5	204

a/ See Appendix 1 for variable definitions.

Table 4. Sample Forecasts--Fluid Milk Products Report

YEAR	QFMWS M lbs	QFMRD M lbs	DFM M lbs	PFMR ¢/Hgal	PI $/cwt	DIFFI $/cwt
1982	50737.4	47237.4	3500.	111.1	14.90	1.95
1983	50863.6	47363.6	3500.	111.1	14.22	1.95
1984	51093.9	47593.9	3500.	109.6	13.55	1.95
1985	51272.6	47772.6	3500.	108.1	12.87	1.95
1986	50975.6	47475.6	3500.	111.8	13.23	1.95
1987	50445.9	46945.9	3500.	118.3	14.17	1.95
1988	49995.5	46495.5	3500.	122.2	14.54	1.95
1989	49708.6	46208.6	3500.	125.9	14.83	1.95
1990	49497.5	45997.5	3500.	128.3	14.83	1.95

Table 5. Sample Forecasts--Frozen Desserts Report

YEAR	QFDWS M lbs	QFDRD Mlbs ME	QFDM M lbs	MFD M lbs	PICR ¢/Hgal	PICW 67=100	PGB $/cwt	CPISSP 67=100
1982	12312.8	12004.8	208.	100.	190.	408.4	12.95	372.5
1983	12897.6	12574.6	208.	115.	178.	392.2	12.27	397.4
1984	13420.6	13097.6	208.	115.	167.	376.0	11.60	423.9
1985	13895.9	13572.9	208.	115.	155.	359.7	10.92	451.9
1986	14028.6	13705.6	208.	115.	159.	368.4	11.28	481.6
1987	13995.4	13672.4	208.	115.	171.	391.0	12.22	513.2
1988	14097.7	13774.7	208.	115.	175.	399.8	12.59	546.6
1989	14245.6	13922.6	208.	115.	178.	406.7	12.88	581.9
1990	14456.2	14133.2	208.	115.	176.	406.7	12.88	619.5

Table 6. Sample Forecasts--American Cheese Report

YEAR	QACWS M lbs	QACRD M lbs	SACC M lbs	SACG M lbs	MAC M lbs	XAC M lbs	DAC M lbs	QACM M lbs
1982	2567.8	2154.3	354.6	738.1	18.	44.	171.	13.
1983	2476.3	2260.2	362.1	805.7	18.	18.	131.	10.
1984	2380.1	2375.5	374.7	669.7	18.	18.	118.	10.
1985	2283.9	2499.5	384.3	330.5	18.	18.	104.	10.
1986	2334.9	2570.2	378.5	1.1	18.	18.	90.	10.
1987	2687.6	2612.0	369.2	.0	18.	18.	76.	10.
1988	2796.5	2714.3	378.4	.0	18.	18.	63.	10.
1989	2855.6	2795.0	380.0	.0	18.	18.	49.	10.
1990	2947.4	2896.2	386.2	.0	18.	18.	35.	10.

YEAR	PACR @/Hlb	PACW @/lb	PACS @/lb	PGB $/lb	CPIMPF 67=100
1982	122.3	145.8	139.5	12.95	262.1
1983	116.4	138.5	132.5	12.27	295.4
1984	110.4	131.0	125.3	11.60	312.8
1985	104.3	123.4	118.0	10.92	331.2
1986	107.5	127.4	121.9	11.28	350.8
1987	116.0	138.0	132.0	12.22	371.5
1988	119.3	142.1	135.9	12.59	393.4
1989	121.9	145.3	139.0	12.88	416.7
1990	121.9	145.3	139.0	12.88	441.3

Table 7. Sample Forecasts--Butter Report

YEAR	QBWS M lbs	QBRD M lbs	SBC M lbs	SBG M lbs	MB M lbs	XB M lbs	DB M lbs	QBM M lbs
1982	1303.5	883.4	65.4	418.0	3.	171.	178.	20.
1983	1377.8	896.0	86.3	742.8	2.	4.	130.	4.
1984	1376.3	909.7	106.1	1063.6	2.	4.	120.	4.
1985	1366.0	929.3	124.6	1365.8	2.	4.	110.	4.
1986	1314.0	942.4	143.2	1612.7	2.	4.	100.	4.
1987	1318.8	952.1	164.4	1862.3	2.	4.	90.	4.
1988	1350.6	970.3	185.0	2135.9	2.	4.	80.	4.
1989	1385.0	989.1	207.5	2433.3	2.	4.	70.	4.
1990	1416.8	1009.7	230.6	2751.3	2.	4.	60.	4.

YEAR	PBR @/lb	PBW @/lb	PBS @/lb	PGB $/cwt	PO @/lb
1982	205.9	150.8	149.0	12.95	82.1
1983	198.4	142.8	141.1	12.27	86.9
1984	189.6	134.9	133.3	11.60	91.9
1985	180.9	127.0	125.5	10.92	97.3
1986	187.9	131.2	129.6	11.28	103.0
1987	203.8	142.2	140.5	12.22	109.0
1988	211.1	146.5	144.7	12.59	115.3
1989	217.4	149.9	148.1	12.88	122.1
1990	219.5	149.9	148.1	12.88	129.3

Table 8. Sample Forecasts--Nonfat Dry Milk Report

YEAR	QNDMWS M lbs	QNDMWD M lbs	SNDMC M lbs	SNDMG M lbs	MNDM M lbs	XNDM M lbs	DNDM M lbs	AFNDM M lbs	QNDMM M lbs
1982	1595.2	556.5	101.2	1375.4	2.	318.	61.	64.	11.
1983	1719.7	598.4	110.4	2084.8	2.	300.	45.	58.	2.
1984	1717.1	617.4	115.3	2783.0	2.	300.	45.	52.	2.
1985	1699.9	635.2	118.4	3453.9	2.	300.	45.	46.	2.
1986	1612.7	613.4	137.6	4050.3	2.	300.	45.	39.	2.
1987	1620.9	568.7	168.8	4693.7	2.	300.	45.	33.	2.
1988	1674.1	544.4	190.2	5430.2	2.	300.	45.	27.	2.
1989	1731.7	523.6	212.8	6250.0	2.	300.	45.	21.	2.
1990	1785.2	513.0	231.7	7143.6	2.	300.	45.	15.	2.

YEAR	PNDMW @/lb	PNDMS @/lb	PGB $/cwt	CPIF 67=100
1982	94.5	94.0	12.95	279.2
1983	89.5	89.0	12.27	295.9
1984	84.5	84.1	11.60	313.2
1985	79.6	79.2	10.92	332.5
1986	82.2	81.8	11.28	352.4
1987	89.1	88.6	12.22	373.6
1988	91.8	91.3	12.59	396.0
1989	93.9	93.4	12.88	419.7
1990	93.9	93.4	12.88	444.9

Table 9. Sample Forecasts--Miscellaneous Retail-Wholesale Report

YEAR	CE M $	CDME Mlbs ME	INC B $	CPINF 67=100	CPIAF 67=100	WR $/hr	WW $/hr
1982	40916.7	121384.0	1968.8	272.4	285.7	7.42	8.10
1983	40774.7	125248.0	2086.9	288.8	302.8	8.55	8.74
1984	40215.0	129339.0	2212.1	306.1	321.0	9.14	9.30
1985	39570.7	133534.0	2344.9	324.4	340.3	9.75	9.89
1986	41286.9	135000.0	2485.6	343.9	360.7	10.41	10.53
1987	44419.7	135076.0	2634.7	364.3	382.3	11.11	11.21
1988	46311.6	136904.0	2792.7	379.7	405.3	11.84	11.91
1989	48045.9	138753.0	2960.4	401.9	429.6	12.62	12.66
1990	49124.2	141286.0	3137.9	424.9	455.4	13.45	13.46

YEAR	SMEC B lbs	MME B lbs	PROAC M lbs	PROB M lbs	PROFD M lbs	PROFM M lbs
1982	5.69	2.42	.00	.00	.00	.00
1983	6.23	2.44	.00	.00	.00	.00
1984	6.78	2.51	.00	.00	.00	.00
1985	7.27	2.58	.00	.00	.00	.00
1986	7.67	2.64	.00	.00	.00	.00
1987	8.13	2.71	.00	.00	.00	.00
1988	8.72	2.77	.00	.00	.00	.00
1989	9.27	2.84	.00	.00	.00	.00
1990	9.88	2.90	.00	.00	.00	.00

Table 10. Sample Forecasts--Raw Milk Report

YEAR	QRM M lbs	PPC lbs	NC Thous	NH Thous	PRM $/cwt	PF $/cwt	PBF $/cwt	AI t-3 % cows
1982	135506.0	12079.8	11217.6	4522.7	13.95	7.55	39.96	62.2
1983	140269.0	12166.0	11529.6	4448.1	13.24	7.75	39.35	63.2
1984	140184.0	12249.1	11444.4	4333.2	12.56	7.98	39.74	64.1
1985	139547.0	12329.1	11318.5	4130.9	11.88	8.22	40.14	65.0
1986	136238.0	12410.3	10977.8	4105.6	12.26	8.47	40.54	65.8
1987	136529.0	12737.5	10718.7	4139.0	13.20	8.39	40.95	66.6
1988	138537.0	12914.8	10727.0	4138.6	13.56	8.30	40.13	67.4
1989	140715.0	13066.2	10769.4	4175.1	13.84	8.22	39.32	68.2
1990	142738.0	13156.2	10849.5	4179.0	13.83	8.14	38.54	68.9

YEAR	GPI M$	FEE $/cwt	BIO lbs	DIVERT Thous
1982	18.9	.00	1.00	.00
1983	18.6	.00	1.00	.00
1984	17.6	.00	1.00	.00
1985	16.5	.00	1.00	.00
1986	16.7	.00	1.00	.00
1987	18.0	.00	1.00	.00
1988	18.8	.00	1.00	.00
1989	19.5	.00	1.00	.00
1990	19.8	.00	1.00	.00

Table 11. Sample Forecasts--Government Report

YEAR	NGP M $	NRME M lbS	NRAC M lbS	NRB M lbS	NRNDM M lbS	PACS @/lb	PBS @/lb	PNDMS @/lb
1982	1989.9	14123.6	509.9	426.4	1004.0	139.5	149.0	94.0
1983	2010.8	15023.0	232.9	508.1	1112.7	132.5	141.1	89.0
1984	1372.5	10847.0	-38.7	492.5	1100.9	125.3	133.3	84.1
1985	717.1	6015.3	-310.8	460.9	1072.0	118.0	125.5	79.2
1986	152.7	1240.6	-316.2	388.5	993.4	121.9	129.6	81.8
1987	194.0	1455.7	77.8	380.5	1043.0	132.0	140.5	88.6
1988	224.5	1635.7	62.9	396.0	1141.2	135.9	144.7	91.3
1989	275.9	1964.7	45.3	411.3	1229.2	139.0	148.1	93.4
1990	204.2	1454.2	27.8	423.0	1307.1	139.0	148.1	93.4

Suggestions for Future Research and Model Applications

Although the authors feel this model exhibits a reasonable level of likely error and is suitable for policy and other economic analyses, especially comparative analyses, there clearly is room for further improvement. As the model validation statistics indicate, the estimates of support program variables exhibit uncomfortably high levels of error. In part due to the validation results and in part due to intuition, the authors attribute the errors in these residual variables much more to errors in demand equations than to error in farm supply. Cross-sectional studies have indicated that sociodemographic variables may play a more important role in determining consumption levels and changes in consumption than do the traditional economic variables--prices and income--used in most time series models such as this one (cf. Boehm and Babb, Morehart, and Raunikar *et al.*). This suggests that better demand estimates may require more effort to incorporate such variables into the model. Commercial stocks equations, although improved over the earlier versions reported by Novakovic and Thompson, also continue to be troublesome.

Despite these imperfections, a wide variety of analyses is possible with the model, including standard impact analyses with exogenous variables and analyses of alternative federal dairy policies. The latter could encompass changes in price support levels, producer assessments, promotion programs, supply controls, a variety of trigger mechanisms, changes in import quotas, and aggregate changes in federal order Class I differentials.

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Appendix 1

A Catalog of the Variables

CDME = commercial disappearance of all dairy products, billion pounds milk equivalent ([16], 6/83 Table 17, and various issues)[1/]

CE = consumer expenditure for all dairy products, millions of dollars ([16], 9/83 Table 6 and various issues)

GPI = gross producer income; cash receipts from farm marketings of milk and cream, million dollars ([16] various issues)

NC = thousands of cows and heifers two year old and over kept for milk, on farms January in year t + 1 (since 1969: [16] various issues, prior to 1969 estimates are made relative to a different data set on cattle numbers[2/])

NGP = net government expenditures, million dollars

NH = thousands of one to two year old heifers kept for milk cows, on farms January 1 in year t + 1 (since 1969: [16] various issues, prior to 1969 estimates are made relative to a different data set on cattle numbers)

NRAC, NRB, NRNDM, NRME = net removals of American cheese (AC), butter (B), nonfat dry milk (NDM) and milk equivalent (ME) from commercial markets by programs of the USDA, million pounds ([16], 3/83 Table 20 and various issues)

1/ Numbers in brackets refer to sources listed in the bibliography.

2/ Prior to 1970, dairy cattle inventories were reported for cows, heifers, and heifer calves--groupings by age. The current series groups cows and replacement heifers by weight. An unpublished data series was obtained from USDA which extended the current series back to 1949. Using observations from 1949 to 1969, the following simple linear regressions were calculated:

$$NC = 892.914 + .91343\ NC^{\circ}$$

$$NH = -996.775 + 1.3758\ NH^{\circ}$$

where

NC° = thousands of cows and heifers two years old and over kept for milk, on farms January 1 in year t+1.

NH° = thousands of one to two year old heifers kept for milk cows, on farms January 1 in year t+1.

These estimates were further adjusted by the differences between the estimated values and actual observations in 1969; the adjustments were -192 for NC and +76 for NH.

PACR = average retail price of cheese in leading cities, in cents per ½ pound package ([24] various issues) (for 1977-81 [16], retail price index * 1977 value)

PACW = average wholesale price of American cheddars at Wisconsin assembling points--(40 pound block) in cents per pound, f.o.b. ([24] various issues, [16])

PBR = average retail price of butter in leading cities in cents per pound ([24] various issues, [16])

PBW = average wholesale price of 92-score butter in Chicago in cents per pound ([24] various issues, [16])

PFMR = average retail price of fresh, grocery milk in leading cities, in cents per ½ gallon ([24] various issues, [16])

PGB = average price received by farmers for manufacturing grade milk, in dollars per cwt. ([2] various issues, [16], and [17])

PI = average price received by farmers for milk eligible for the fluid market in dollar per cwt. ([2] various issues, [16], and [17])

PICR = average retail price of ice cream in leading cities, in cents per ½ gallon ([14] various issues, [15], and [16])

PICW = wholesale price index for bulk ice cream, 1967=100 ([88] various issues)

PNDMW = manufacturer's average selling price of nonfat dry milk in cents per pound ([16] various issues, [17], and [18])

PPC = production per cow, in pounds ([16] various issues)

PRM = average price received by farmers for all milk sold to plants, dollars per cwt. ([2] various issues, and [16])

QACRD = commercial civilian disappearance of American cheese excluding donations, in millions of pounds ([16] various issues)

QACWS = production of American cheese (cheddar plus other American), in millions of pounds ([23] various issues)

QBRD = commercial civilian disappearance of butter excluding donations, in millions of pounds ([23] and [16])

QBWS = production of butter, in millions of pounds ([23] and [16] various issues)

QFDRD = domestic, civilian disappearance of net milk used in frozen dairy products, in millions of pounds ([23], and [16] various issues)

QFDWS = production of frozen dairy products, in millions of pounds of net milk used ([23], and [16] various issues)

QFMRD = domestic, civilian disappearance of fluid milk and cream products, excluding donations, in millions of pounds of raw milk equivalent ([16] various issues, and [23])

QFMWS = QFMRD + DFM + QFMM, which yields millions of pounds in raw milk equivalent

QNDMWD = domestic, civilian disapperance of nonfat dry milk, in millions of pounds ([23] and [16])

QNDMWS = production of nonfat dry milk, in millions of pounds ([23] and [16])

QRM = total milk production, in millions of pounds ([16] various issues)

SACC, SBC, SNDMC, SMEC = ending commercial stocks of American cheese, butter and nonfat dry milk in millions of pounds ([16] and [23])

SACG, SBG, SNDMG = ending USDA stocks of American cheese (AC), butter (B), nonfat dry milk (NDM) and all milk equivalent (ME) in millions of pounds ([16] and [23])

Exogenous Variables

The following list does not include the exogenous instruments that were developed for policy and other analyses, i.e. FEE, DIVERT PROFM, PROFD, PROAC, PROB and BIO. These variables are discussed in the text.

AFNDM = utilization of nonfat dry milk in animal feed, in millions of pounds ([23])

AI = thousands of dairy cows bred artificially to dairy and beef bulls divided by NC and multiplied by 100, which yields percentage of dairy cows bred artificially. (Number of dairy cows artificially bred is taken from [15].)

CPIAF, CPIF, CPIMPF, CPINF, CPISSP = the Consumer Price Index for all foods (AF), frankfurters (F), meat, poultry, and fish (MPF), nonfoods (NF), and sugar and sweet products (SSP), where 1967=100 ([23])

DIFFI = PI - PGB, which yields dollars per cwt.

DAC, DB, DFM, DNDM = USDA donations of American cheese (AC), butter (B), fluid milk (FM), and nonfat dry milk (NDM), in millions of pounds ([23] for butter and nonfat dry milk, [16] various issues, for American cheese)

MAC, MB, MFD, MNDM = imports of American cheese (AC), butter (B), frozen desserts (FD), and nonfat dry milk (NDM), in millions of pounds ([23] for all other than cheese, [16] various issues, for American cheese)

MME = imports of all dairy products, billion pounds, milk equivalent ([16] 3/83 Table 17 and various issues)

PACS, PBS, PNDMS = USDA purchase price of natural cheddar cheese grade A or higher (AC), butter grade A or higher (B), and nonfat dry milk, extra grade, spray process (NDM), in cents per pound, computed as a yearly average ([16] and [17])

PBF = average price of cows, utility grade, at Omaha, in dollars per cwt. ([3] and [16])

PF = estimated value of concentrate rations fed to milk cows, in dollars per cwt. ([16])

PO = price of colored oleomargarine in leading cities, in cents per pound ([16] various issues, [17], and [18])

QACM, QBM, QFDM, QNDMM = domestic military disappearance of American cheese (AC), butter (B), frozen desserts (FD), and nonfat dry milk (NDM), in millions of pounds [23] for all except cheese and milk, [16] various issues, for American cheese and fluid milk)

WR = average hourly earnings of production and nonsupervisory workers on private nonagricultural payrolls in grocery, meat, and vegetable stores, in dollars per hour ([22] various issues)

WW = average hourly earnings of production and nonsupervisory workers on private nonagricultural payrolls in the dairy industry, in dollars per hour ([22] various issues)

XAC, XB, XNDM = exports and shipments of American cheese (AC), butter (B), and nonfat dry milk (NDM), in millions of pounds ([23] for butter and nonfat dry milk, [16] various issues, for cheese)

V = total disposable income, in billions of dollars ([24], various issues)

Appendix 2

Ex Post Model Estimates

The following tables contain the results of the historical or ex post simulation for the period 1958 to 1982. Variables are presented in alphabetical order by their acronym.

SIMULATION EX POST VARIABLE CDME

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	114959.00	117197.00	2237.87	1.9467
1959	115675.00	116644.00	968.87	.8376
1960	116552.00	116293.00	-258.92	-.2222
1961	114854.00	114386.00	-467.60	-.4071
1962	115272.00	114904.00	-367.88	-.3191
1963	115369.00	115687.00	317.58	.2753
1964	116901.00	115426.00	-1475.24	-1.2620
1965	117493.00	115798.00	-1694.53	-1.4422
1966	117983.00	114016.00	-3966.99	-3.3623
1967	112419.00	112031.00	-388.06	-.3452
1968	111735.00	111467.00	-268.30	-.2401
1969	110738.00	112801.00	2063.07	1.8630
1970	110813.00	113063.00	2250.10	2.0305
1971	111001.00	112745.00	1743.91	1.5711
1972	113235.00	113613.00	378.23	.3340
1973	113244.00	113630.00	386.42	.3412
1974	113656.00	117020.00	3363.83	2.9597
1975	114218.00	120184.00	5965.67	5.2231
1976	117185.00	115836.00	-1348.70	-1.1509
1977	116186.00	115812.00	-373.81	-.3217
1978	118918.00	117956.00	-962.33	-.8092
1979	121079.00	118166.00	-2913.03	-2.4059
1980	119490.00	118695.00	-795.49	-.6657
1981	120557.00	119353.00	-1204.17	-.9988
1982	122500.00	121384.00	-1115.53	-.9106

Root Mean Square Percent Error = .0175

Turning Point Errors = 5. out of a possible 24

SIMULATION EX POST VARIABLE CE

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	11450.00	12098.30	648.31	5.6621
1959	11849.00	12001.20	152.20	1.2845
1960	12098.00	12077.20	-20.76	-.1716
1961	12233.00	12325.20	92.19	.7536
1962	12427.00	12154.30	-272.67	-2.1941
1963	12598.00	12132.80	-465.16	-3.6923
1964	12938.00	12313.80	-624.18	-4.8244
1965	13049.00	12278.40	-770.55	-5.9051
1966	13606.00	13098.80	-507.20	-3.7278
1967	13698.00	13806.30	108.29	.7906
1968	14576.00	14497.90	-78.12	-.5359
1969	15351.00	15023.40	-327.55	-2.1338
1970	16729.00	15883.20	-845.83	-5.0560
1971	15176.00	16543.40	1367.43	9.0105
1972	17957.00	16891.80	-1065.24	-5.9322
1973	19294.00	19076.70	-217.33	-1.1264
1974	21823.00	22103.90	280.95	1.2874
1975	23316.00	23566.30	250.28	1.0734
1976	26386.00	25571.90	-814.08	-3.0853
1977	27441.00	27455.10	14.05	.0512
1978	29606.00	29605.90	-.11	-.0004
1979	33174.00	33082.50	-91.45	-.2757
1980	37600.00	37632.00	32.02	.0852
1981	40335.00	40358.00	22.99	.0570
1982	40335.00	40916.70	581.70	1.4422

Root Mean Square Percent Error = .0339

Turning Point Errors = 4. out of a possible 24

SIMULATION EX POST VARIABLE GPI

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	4.60	4.71	.11	2.4617
1959	4.60	4.62	.02	.3657
1960	4.80	4.67	-.13	-2.6643
1961	4.90	5.05	.15	3.0701
1962	4.90	4.93	.03	.6427
1963	4.90	4.75	-.15	-2.9879
1964	5.00	4.87	-.13	-2.6749
1965	5.00	4.77	-.23	-4.6342
1966	5.50	5.18	-.32	-5.8503
1967	5.70	5.65	-.05	-.9321
1968	6.00	6.17	.17	2.7539
1969	6.20	6.37	.17	2.7396
1970	6.50	6.69	.19	2.8524
1971	6.80	7.13	.33	4.8554
1972	7.10	7.07	-.03	-.3880
1973	8.10	8.25	.15	1.8136
1974	9.40	9.50	.10	1.0341
1975	9.90	9.58	-.32	-3.2342
1976	11.40	10.83	-.57	-5.0355
1977	11.70	11.95	.25	2.1201
1978	12.70	12.65	-.05	-.3983
1979	14.70	14.19	-.51	-3.4419
1980	16.60	16.47	-.13	-.7762
1981	18.40	17.99	-.41	-2.2150
1982	18.30	18.72	.42	2.2836

Root Mean Square Percent Error = .0290

Turning Point Errors = 4. out of a possible 24

SIMULATION EX POST VARIABLE NC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	18220.00	18605.10	385.12	2.1137
1959	17650.00	17781.50	131.55	.7453
1960	17390.00	17301.10	-88.91	-.5113
1961	17090.00	16577.10	-512.88	-3.0010
1962	16570.00	16152.10	-417.88	-2.5219
1963	15960.00	15457.10	-502.94	-3.1513
1964	15380.00	15009.20	-370.79	-2.4109
1965	14490.00	14353.70	-136.28	-.9405
1966	13725.00	13742.60	17.59	.1282
1967	13115.00	13434.90	319.86	2.4389
1968	12550.00	13033.10	483.10	3.8494
1969	12091.00	12818.20	727.15	6.0140
1970	11909.00	12474.90	565.90	4.7519
1971	11776.00	12347.20	571.16	4.8502
1972	11627.00	11872.30	245.30	2.1098
1973	11297.00	11569.90	272.92	2.4159
1974	11220.00	11308.60	88.62	.7899
1975	11071.00	11089.60	18.56	.1676
1976	10998.00	10876.00	-122.02	-1.1094
1977	10896.00	10876.10	-19.90	-.1827
1978	10790.00	10595.50	-194.52	-1.8028
1979	10779.00	10503.40	-275.62	-2.5570
1980	10860.00	10644.70	-215.29	-1.9824
1981	10998.00	10876.70	-121.25	-1.1025
1982	11026.00	11136.10	110.06	.9982

Root Mean Square Percent Error = .0260

Turning Point Errors = 6. out of a possible 24

SIMULATION EX POST VARIABLE NGP

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	260.85	191.54	-69.30	-26.5681
1959	192.89	143.89	-49.00	-25.4044
1960	197.38	197.37	-.01	-.0051
1961	376.41	421.81	45.40	12.0626
1962	453.98	407.92	-46.06	-10.1453
1963	374.45	267.86	-106.59	-28.4655
1964	385.97	302.37	-83.60	-21.6589
1965	296.91	223.58	-73.33	-24.6988
1966	115.46	217.61	102.14	88.4666
1967	391.44	336.13	-55.31	-14.1293
1968	261.93	521.70	259.78	99.1783
1969	220.49	527.13	306.64	139.0730
1970	300.27	449.74	149.47	49.7770
1971	364.19	567.67	203.48	55.8734
1972	323.95	396.42	72.47	22.3714
1973	114.10	312.30	198.20	173.7030
1974	200.67	-45.91	-246.58	-122.8810
1975	382.01	-358.20	-740.21	-193.7670
1976	138.82	186.17	47.34	34.1045
1977	689.47	565.39	-124.09	-17.9975
1978	360.08	386.78	26.70	7.4157
1979	182.91	451.06	268.15	146.6000
1980	1129.32	791.76	-337.56	-29.8903
1981	1598.84	1272.10	-326.74	-20.4362
1982	1598.84	1761.19	162.35	10.1544

Root Mean Square Percent Error = .7850

Turning Point Errors = 7. out of a possible 24

SIMULATION EX POST VARIABLE NH

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	5862.00	5925.80	63.80	1.0883
1959	5686.00	5717.18	31.18	.5484
1960	5435.00	5471.70	36.70	.6752
1961	5349.00	5269.05	-79.95	-1.4947
1962	5186.00	5027.54	-158.46	-3.0554
1963	4978.00	4863.46	-114.54	-2.3009
1964	4780.00	4651.78	-128.22	-2.6825
1965	4450.00	4478.08	28.08	.6309
1966	4215.00	4365.27	150.27	3.5650
1967	4080.00	4245.54	165.54	4.0573
1968	3990.00	4123.28	133.28	3.3403
1969	3880.00	4011.04	131.04	3.3774
1970	3843.00	3988.59	145.59	3.7884
1971	3828.00	3929.49	101.49	2.6512
1972	3872.00	3854.94	-17.06	-.4407
1973	3941.00	3932.23	-8.77	-.2226
1974	4087.00	4000.65	-86.35	-2.1129
1975	3956.00	3849.89	-106.11	-2.6823
1976	3887.00	3874.55	-12.45	-.3203
1977	3886.00	3892.28	6.28	.1617
1978	3932.00	3957.85	25.85	.6574
1979	4158.00	4132.55	-25.45	-.6121
1980	4345.00	4379.92	34.92	.8036
1981	4530.00	4528.25	-1.75	-.0386
1982	4520.00	4510.18	-9.82	-.2172

Root Mean Square Percent Error = .0213

Turning Point Errors = 6. out of a possible 24

SIMULATION EX POST VARIABLE NRAC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	75.00	294.80	219.80	293.0730
1959	57.20	321.18	263.98	461.4950
1960	.30	202.44	202.14	67379.0000
1961	100.00	225.48	125.48	125.4760
1962	212.90	111.39	-101.51	-47.6785
1963	110.90	50.07	-60.83	-54.8531
1964	128.50	-23.26	-151.76	-118.1010
1965	48.60	-111.33	-159.93	-329.0720
1966	10.80	-93.63	-104.43	-966.9710
1967	180.50	9.55	-170.95	-94.7104
1968	87.50	-4.57	-92.07	-105.2240
1969	27.70	94.20	66.50	240.0880
1970	48.90	39.06	-9.84	-20.1181
1971	90.70	80.42	-10.28	-11.3353
1972	30.40	45.33	14.93	49.1066
1973	3.20	-8.56	-11.76	-367.5150
1974	60.30	51.59	-8.71	-14.4369
1975	68.20	82.93	14.73	21.5914
1976	38.00	134.53	96.53	254.0320
1977	148.20	133.37	-14.83	-10.0040
1978	39.70	73.80	34.10	85.8849
1979	40.20	214.39	174.19	433.3010
1980	349.70	561.72	212.02	60.6288
1981	563.00	558.81	-4.19	-.7451
1982	642.50	467.81	-174.69	-27.1885

Root Mean Square Percent Error = 134.7860

Turning Point Errors = 7. out of a possible 24

SIMULATION EX POST VARIABLE NRB

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	183.70	122.47	-61.23	-33.3330
1959	123.70	158.34	34.64	28.0064
1960	144.80	164.55	19.75	13.6391
1961	329.40	246.81	-82.59	-25.0734
1962	402.70	276.33	-126.37	-31.3800
1963	307.50	260.05	-47.45	-15.4324
1964	295.70	503.93	208.23	70.4207
1965	241.00	307.59	66.59	27.6300
1966	25.10	298.69	273.59	1090.0200
1967	265.10	329.30	64.20	24.2171
1968	194.80	313.66	118.86	61.0178
1969	187.90	358.84	170.94	90.9733
1970	246.40	329.04	82.64	33.5379
1971	292.20	319.68	27.48	9.4060
1972	233.70	289.39	55.69	23.8317
1973	97.70	146.03	48.33	49.4728
1974	32.70	-140.94	-173.64	-531.0020
1975	63.40	-107.76	-171.16	-269.9670
1976	39.40	50.71	11.31	28.6942
1977	221.80	169.43	-52.37	-23.6103
1978	112.00	189.48	77.48	69.1795
1979	81.60	214.43	132.83	162.7850
1980	257.00	268.65	11.65	4.5323
1981	351.50	343.49	-8.01	-2.2783
1982	382.20	399.27	17.07	4.4657

Root Mean Square Percent Error = 2.5315

Turning Point Errors = 8. out of a possible 24

SIMULATION EX POST VARIABLE NRME

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	4658.00	5693.44	1035.44	22.2292
1959	3214.00	4349.99	1135.99	35.3450
1960	3101.00	5877.29	2776.29	89.5287
1961	8019.00	11604.20	3585.20	44.7088
1962	10724.00	11513.20	789.24	7.3595
1963	7745.00	7502.35	-242.65	-3.1329
1964	7676.00	8409.58	733.58	9.5568
1965	5665.00	6152.48	487.48	8.6050
1966	645.00	5289.74	4644.74	720.1140
1967	7427.00	7607.01	180.01	2.4237
1968	5159.00	11182.90	6023.91	116.7650
1969	4479.00	10930.10	6451.06	144.0290
1970	5774.00	8731.12	2957.12	51.2144
1971	7268.00	10396.80	3128.78	43.0488
1972	5345.00	7168.79	1823.79	34.1214
1973	2185.00	5032.70	2847.70	130.3290
1974	1346.00	-655.89	-2001.89	-148.7290
1975	2036.00	-4422.68	-6458.68	-317.2240
1976	1236.00	2058.10	822.10	66.5129
1977	6080.00	5793.11	-286.89	-4.7186
1978	2743.00	3731.37	988.37	36.0326
1979	2119.00	3883.45	1764.45	83.2680
1980	8800.00	5944.22	-2855.78	-32.4521
1981	12861.00	9015.12	-3845.88	-29.9034
1982	14287.00	12500.00	-1786.96	-12.5076

Root Mean Square Percent Error = 1.7031

Turning Point Errors = 8. out of a possible 24

SIMULATION EX POST VARIABLE NRNDM

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	886.00	928.93	42.93	4.8448
1959	830.30	853.10	22.80	2.7457
1960	852.80	916.17	63.37	7.4303
1961	1085.60	967.33	-118.27	-10.8941
1962	1386.10	965.86	-420.24	-30.3185
1963	1219.20	1082.80	-136.40	-11.1875
1964	1168.80	1572.32	403.52	34.5245
1965	1098.40	1090.07	-8.33	-.7581
1966	365.80	627.98	262.18	71.6721
1967	687.00	623.22	-63.78	-9.2837
1968	577.80	649.21	71.41	12.3588
1969	407.20	652.49	245.29	60.2377
1970	451.60	577.20	125.60	27.8133
1971	456.20	532.15	75.95	16.6493
1972	345.00	438.93	93.93	27.2265
1973	36.80	302.28	265.48	721.4170
1974	265.00	-4.88	-269.88	-101.8430
1975	394.50	224.94	-169.56	-42.9805
1976	157.10	264.19	107.09	68.1642
1977	461.70	430.43	-31.27	-6.7733
1978	285.00	450.03	165.03	57.9056
1979	255.70	511.47	255.77	100.0260
1980	634.30	563.80	-70.50	-11.1140
1981	851.30	871.98	20.68	2.4291
1982	952.90	956.91	4.01	.4205

Root Mean Square Percent Error = 1.5021

Turning Point Errors = 6. out of a possible 24

SIMULATION EX POST VARIABLE PACR

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	29.00	33.33	4.33	14.9276
1959	29.10	32.86	3.76	12.9208
1960	34.30	33.28	-1.02	-2.9774
1961	36.40	35.57	-.83	-2.2700
1962	36.20	34.81	-1.39	-3.8356
1963	36.30	35.04	-1.26	-3.4775
1964	36.70	35.25	-1.45	-3.9589
1965	37.70	35.57	-2.13	-5.6622
1966	42.20	39.54	-2.66	-6.2941
1967	43.80	42.07	-1.73	-3.9420
1968	44.40	44.12	-.28	-.6371
1969	47.00	45.42	-1.58	-3.3537
1970	50.40	48.15	-2.25	-4.4723
1971	52.80	50.71	-2.09	-3.9603
1972	54.30	51.29	-3.01	-5.5490
1973	60.40	63.22	2.82	4.6737
1974	72.90	69.81	-3.09	-4.2322
1975	76.80	72.60	-4.20	-5.4751
1976	86.50	80.44	-6.06	-7.0019
1977	86.00	86.37	.37	.4246
1978	90.10	91.39	1.29	1.4325
1979	101.20	101.75	.55	.5451
1980	111.40	115.89	4.49	4.0306
1981	120.70	122.45	1.75	1.4486
1982	123.80	122.27	-1.53	-1.2338

Root Mean Square Percent Error = .0549

Turning Point Errors = 6. out of a possible 24

SIMULATION EX POST VARIABLE PACW

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	33.70	34.82	1.12	3.3342
1959	33.20	34.24	1.04	3.1270
1960	36.40	34.76	-1.64	-4.5031
1961	37.20	37.63	.43	1.1435
1962	36.20	36.67	.47	1.3095
1963	36.60	36.96	.36	.9735
1964	37.60	37.22	-.38	-1.0168
1965	38.30	37.61	-.69	-1.7887
1966	45.90	42.58	-3.32	-7.2314
1967	45.10	45.74	.64	1.4146
1968	47.60	48.29	.69	1.4472
1969	51.90	49.92	-1.98	-3.8155
1970	55.00	53.32	-1.68	-3.0592
1971	56.50	56.52	.02	.0292
1972	59.80	57.24	-2.56	-4.2845
1973	72.60	72.14	-.46	-.6393
1974	79.90	80.36	.46	.5801
1975	86.60	83.83	-2.77	-3.1942
1976	96.60	93.63	-2.97	-3.0749
1977	96.80	101.02	4.22	4.3604
1978	107.10	107.29	.19	.1807
1979	132.60	120.23	-12.37	-9.3321
1980	133.00	137.87	4.87	3.6636
1981	139.40	146.06	6.66	4.7765
1982	138.30	145.84	7.54	5.4511

Root Mean Square Percent Error = .0369

Turning Point Errors = 2. out of a possible 24

SIMULATION EX POST VARIABLE PBR

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	74.20	72.97	-1.23	-1.6550
1959	75.30	72.62	-2.68	-3.5593
1960	74.90	74.00	-.90	-1.2014
1961	76.30	76.34	.04	.0587
1962	75.20	74.06	-1.14	-1.5146
1963	75.00	73.41	-1.59	-2.1154
1964	74.40	76.23	1.83	2.4546
1965	75.40	74.78	-.62	-.8192
1966	82.20	80.87	-1.33	-1.6179
1967	83.70	85.34	1.64	1.9634
1968	83.60	85.74	2.14	2.5569
1969	84.60	85.96	1.36	1.6098
1970	86.60	90.24	3.64	4.2032
1971	87.60	89.45	1.85	2.1094
1972	87.10	89.38	2.28	2.6190
1973	91.60	93.92	2.32	2.5331
1974	94.60	92.28	-2.32	-2.4520
1975	102.50	96.70	-5.80	-5.6597
1976	126.10	115.89	-10.21	-8.0934
1977	133.10	133.41	.31	.2326
1978	150.20	145.21	-4.99	-3.3231
1979	169.00	166.20	-2.80	-1.6562
1980	187.80	192.29	4.49	2.3911
1981	199.30	205.72	6.42	3.2223
1982	204.60	205.95	1.35	.6576

Root Mean Square Percent Error = .0293

Turning Point Errors = 4. out of a possible 24

SIMULATION EX POST VARIABLE PBW

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	58.70	58.88	.18	.3017
1959	59.70	58.60	-1.10	-1.8343
1960	59.10	59.50	.40	.6809
1961	60.50	61.18	.68	1.1291
1962	58.40	59.29	.89	1.5169
1963	58.20	58.65	.45	.7792
1964	59.10	60.68	1.58	2.6687
1965	60.20	59.41	-.79	-1.3117
1966	66.60	63.97	-2.63	-3.9553
1967	66.70	67.25	.55	.8310
1968	66.90	67.28	.38	.5629
1969	67.70	67.13	-.57	-.8422
1970	69.40	70.12	.72	1.0329
1971	68.40	69.11	.71	1.0366
1972	68.60	68.53	-.07	-.1017
1973	69.80	68.74	-1.06	-1.5162
1974	65.70	66.76	1.06	1.6111
1975	79.40	72.38	-7.02	-8.8421
1976	92.00	86.58	-5.42	-5.8937
1977	98.00	99.40	1.40	1.4307
1978	109.80	107.62	-2.18	-1.9860
1979	122.40	123.00	.60	.4899
1980	139.30	142.04	2.74	1.9654
1981	148.00	150.99	2.99	2.0201
1982	147.70	150.77	3.07	2.0766

Root Mean Square Percent Error = .0263

Turning Point Errors = 3. out of a possible 24

SIMULATION EX POST VARIABLE PFMR

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	46.70	45.70	-1.00	-2.1347
1959	47.20	45.72	-1.48	-3.1445
1960	48.30	46.08	-2.22	-4.5884
1961	48.20	47.03	-1.17	-2.4312
1962	47.80	46.88	-.92	-1.9200
1963	47.60	46.78	-.82	-1.7191
1964	47.70	47.48	-.22	-.4690
1965	47.30	47.56	.26	.5544
1966	49.80	49.76	-.04	-.0737
1967	51.70	52.38	.68	1.3111
1968	53.70	54.91	1.21	2.2579
1969	55.10	56.09	.99	1.7909
1970	57.40	58.11	.71	1.2354
1971	58.90	60.18	1.28	2.1693
1972	59.80	61.22	1.42	2.3688
1973	64.00	66.43	2.43	3.7955
1974	76.80	74.19	-2.61	-3.3992
1975	76.90	74.40	-2.50	-3.2471
1976	81.00	80.91	-.09	-.1171
1977	82.10	84.37	2.27	2.7596
1978	86.10	87.93	1.83	2.1282
1979	96.00	95.01	-.99	-1.0364
1980	104.90	104.08	-.82	-.7810
1981	111.70	110.56	-1.14	-1.0196
1982	112.40	111.11	-1.29	-1.1476

Root Mean Square Percent Error = .0222

Turning Point Errors = 5. out of a possible 24

SIMULATION EX POST VARIABLE PGB

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	3.15	3.23	.08	2.4565
1959	3.17	3.18	.01	.3162
1960	3.25	3.19	-.06	-1.7770
1961	3.36	3.43	.07	1.9735
1962	3.20	3.30	.10	3.2437
1963	3.21	3.27	.06	1.8918
1964	3.26	3.33	.07	2.0504
1965	3.34	3.32	-.02	-.7038
1966	3.97	3.74	-.23	-5.9026
1967	4.06	4.01	-.05	-1.1145
1968	4.22	4.23	.01	.2622
1969	4.45	4.33	-.12	-2.6375
1970	4.70	4.66	-.04	-.8418
1971	4.86	4.96	.10	2.1344
1972	5.08	5.03	-.05	-.9673
1973	6.20	6.17	-.03	-.4601
1974	7.13	7.17	.04	.4922
1975	7.63	7.48	-.15	-1.9330
1976	8.56	8.18	-.38	-4.4534
1977	8.70	8.93	.23	2.6309
1978	9.65	9.54	-.11	-1.1316
1979	11.10	10.72	-.38	-3.4294
1980	12.00	12.25	.25	2.1142
1981	12.70	12.97	.27	2.1444
1982	12.67	12.95	.28	2.2087

Root Mean Square Percent Error = .0236

Turning Point Errors = 1. out of a possible 24

SIMULATION EX POST   VARIABLE PI

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	4.72	4.80	.08	1.6394
1959	4.79	4.80	.01	.2093
1960	4.88	4.82	-.06	-1.1834
1961	4.91	4.98	.07	1.3505
1962	4.80	4.90	.10	2.1625
1963	4.78	4.84	.06	1.2704
1964	4.87	4.94	.07	1.3726
1965	4.93	4.91	-.02	-.4768
1966	5.55	5.32	-.23	-4.2222
1967	5.85	5.80	-.05	-.7735
1968	6.23	6.24	.01	.1776
1969	6.50	6.38	-.12	-1.8057
1970	6.74	6.70	-.04	-.5870
1971	6.90	7.00	.10	1.5033
1972	7.10	7.05	-.05	-.6921
1973	8.03	8.00	-.03	-.3553
1974	9.35	9.39	.04	.3753
1975	9.36	9.21	-.15	-1.5757
1976	10.74	10.36	-.38	-3.5494
1977	10.62	10.85	.23	2.1552
1978	11.41	11.30	-.11	-.9571
1979	12.88	12.50	-.38	-2.9555
1980	13.77	14.02	.25	1.8424
1981	14.69	14.91	.22	1.5135
1982	14.72	14.90	.18	1.2218

Root Mean Square Percent Error = .0174

Turning Point Errors = 3. out of a possible 24

SIMULATION EX POST   VARIABLE PICR

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	84.40	83.80	-.60	-.7132
1959	84.40	81.58	-2.82	-3.3391
1960	83.50	80.24	-3.26	-3.9066
1961	83.20	82.14	-1.06	-1.2707
1962	82.50	78.83	-3.67	-4.4534
1963	81.80	76.82	-4.98	-6.0895
1964	80.40	76.12	-4.28	-5.3261
1965	78.70	74.44	-4.26	-5.4086
1966	80.60	79.06	-1.54	-1.9121
1967	81.70	81.62	-.08	-.0944
1968	80.70	83.27	2.57	3.1818
1969	81.30	83.23	1.93	2.3766
1970	84.50	86.51	2.01	2.3783
1971	85.40	89.43	4.03	4.7169
1972	85.80	88.89	3.09	3.5996
1973	91.00	93.04	2.04	2.2432
1974	107.60	106.07	-1.53	-1.4231
1975	122.30	120.22	-2.08	-1.6999
1976	127.10	128.89	1.79	1.4117
1977	135.20	138.36	3.16	2.3341
1978	141.60	145.79	4.19	2.9615
1979	158.20	161.53	3.33	2.1041
1980	182.30	182.47	.17	.0958
1981	201.60	191.48	-10.12	-5.0222
1982	210.20	189.62	-20.58	-9.7892

Root Mean Square Percent Error = .0377

Turning Point Errors = 3. out of a possible 24

SIMULATION EX POST VARIABLE PICW

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	179.20	175.08	-4.12	-2.2972
1959	179.00	173.95	-5.05	-2.8229
1960	176.20	174.24	-1.96	-1.1121
1961	177.20	179.86	2.66	1.4993
1962	177.40	176.92	-.48	-.2722
1963	178.70	176.12	-2.58	-1.4418
1964	180.50	177.47	-3.03	-1.6787
1965	181.60	177.22	-4.38	-2.4110
1966	188.20	187.28	-.92	-.4890
1967	192.60	193.98	1.38	.7145
1968	196.10	199.17	3.07	1.5638
1969	200.50	201.60	1.10	.5505
1970	208.60	209.47	.87	.4167
1971	214.20	216.75	2.55	1.1890
1972	216.90	218.36	1.46	.6721
1973	224.80	227.66	2.86	1.2713
1974	254.20	251.50	-2.70	-1.0623
1975	276.40	277.18	.78	.2839
1976	290.30	293.89	3.59	1.2373
1977	303.20	311.89	8.69	2.8662
1978	331.90	326.57	-5.33	-1.6049
1979	354.90	354.85	-.05	-.0135
1980	387.00	391.67	4.67	1.2065
1981	419.70	408.91	-10.79	-2.5703
1982	454.30	408.37	-45.93	-10.1094

Root Mean Square Percent Error = .0252

Turning Point Errors = 5. out of a possible 24

SIMULATION EX POST VARIABLE PNDMW

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	14.10	14.77	.67	4.7741
1959	13.60	14.33	.73	5.3725
1960	13.70	13.86	.16	1.1532
1961	15.70	15.91	.21	1.3347
1962	14.90	14.98	.08	.5660
1963	14.50	14.48	-.02	-.1276
1964	14.60	14.48	-.12	-.8116
1965	14.70	14.63	-.07	-.4602
1966	18.20	17.70	-.50	-2.7494
1967	19.90	19.71	-.19	-.9501
1968	22.40	22.36	-.04	-.1972
1969	23.50	23.42	-.08	-.3327
1970	26.30	26.36	.06	.2219
1971	30.70	30.75	.05	.1729
1972	33.10	31.88	-1.22	-3.6875
1973	46.40	44.96	-1.44	-3.1089
1974	58.60	60.04	1.44	2.4614
1975	63.60	61.55	-2.05	-3.2289
1976	63.50	62.75	-.75	-1.1761
1977	66.50	66.98	.48	.7172
1978	71.40	71.30	-.10	-.1382
1979	80.00	79.35	-.65	-.8168
1980	88.70	89.81	1.11	1.2463
1981	93.90	94.73	.83	.8873
1982	93.20	94.53	1.33	1.4292

Root Mean Square Percent Error = .0211

Turning Point Errors = 3. out of a possible 24

SIMULATION EX POST   VARIABLE PPC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	6762.89	6605.15	-157.74	-2.3324
1959	6911.55	6804.40	-107.15	-1.5503
1960	7079.30	7061.39	-17.91	-.2530
1961	7355.59	7600.22	244.63	3.3258
1962	7619.25	7826.63	207.38	2.7217
1963	7844.73	7969.68	124.95	1.5928
1964	8255.33	8250.55	-4.78	-.0579
1965	8570.05	8496.04	-74.01	-.8636
1966	8736.75	8681.33	-55.42	-.6344
1967	9053.14	8904.88	-148.26	-1.6377
1968	9340.64	9410.52	69.88	.7481
1969	9602.84	9652.70	49.86	.5192
1970	9825.09	9763.03	-62.06	-.6317
1971	10068.40	9973.16	-95.24	-.9459
1972	10323.00	10173.30	-149.70	-1.4502
1973	10223.20	10255.90	32.71	.3200
1974	10301.80	10289.50	-12.26	-.1190
1975	10423.40	10438.50	15.13	.1451
1976	10927.40	10839.70	-87.71	-.8027
1977	11256.80	11180.80	-76.01	-.6752
1978	11256.80	11484.60	227.83	2.0240
1979	11449.20	11619.80	170.62	1.4903
1980	11834.70	11708.80	-125.91	-1.0639
1981	12059.80	11801.90	-257.94	-2.1388
1982	12059.80	12022.40	-37.36	-.3098

Root Mean Square Percent Error =   .0142

Turning Point Errors = 2. out of a possible 24

SIMULATION EX POST   VARIABLE PRM

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	4.13	4.12	-.01	-.3625
1959	4.16	4.10	-.06	-1.3947
1960	4.21	4.11	-.10	-2.4581
1961	4.22	4.27	.05	1.2860
1962	4.09	4.17	.08	1.9135
1963	4.10	4.14	.04	.9013
1964	4.15	4.20	.05	1.2990
1965	4.23	4.19	-.04	-.9294
1966	4.81	4.62	-.19	-3.9903
1967	5.02	4.99	-.03	-.6668
1968	5.24	5.28	.04	.6758
1969	5.49	5.39	-.10	-1.8166
1970	5.71	5.73	.02	.3182
1971	5.87	6.02	.15	2.5049
1972	6.07	6.09	.02	.2979
1973	7.14	7.16	.02	.2833
1974	8.33	8.35	.02	.2110
1975	8.75	8.46	-.29	-3.3093
1976	9.66	9.34	-.32	-3.3526
1977	9.72	9.95	.23	2.3595
1978	10.60	10.50	-.10	-.9089
1979	12.00	11.70	-.30	-2.4641
1980	13.00	13.24	.24	1.8416
1981	13.80	14.01	.21	1.5094
1982	13.55	13.96	.41	3.0147

Root Mean Square Percent Error =   .0193

Turning Point Errors = 3. out of a possible 24

SIMULATION EX POST VARIABLE QACRD

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	797.00	792.18	-4.82	-.6048
1959	864.00	805.60	-58.40	-6.7598
1960	938.00	859.05	-78.95	-8.4166
1961	1004.00	901.97	-102.03	-10.1620
1962	969.00	972.84	3.84	.3964
1963	1012.00	1039.40	27.40	2.7075
1964	1035.00	1104.04	69.04	6.6701
1965	1098.00	1181.13	83.13	7.5707
1966	1195.00	1265.63	70.63	5.9109
1967	1168.00	1254.08	86.08	7.3700
1968	1191.00	1298.43	107.43	9.0205
1969	1249.00	1353.47	104.47	8.3645
1970	1385.00	1411.22	26.22	1.8929
1971	1445.00	1440.89	-4.11	-.2841
1972	1568.00	1526.66	-41.34	-2.6364
1973	1657.00	1672.98	15.98	.9642
1974	1767.00	1792.44	25.44	1.4396
1975	1689.00	1863.13	174.13	10.3097
1976	1913.00	1841.13	-71.87	-3.7571
1977	1909.00	1889.68	-19.32	-1.0120
1978	2046.00	1995.02	-50.98	-2.4915
1979	2095.00	2043.02	-51.98	-2.4812
1980	2001.00	2012.29	11.29	.5643
1981	2192.00	2089.39	-102.61	-4.6813
1982	2194.00	2154.27	-39.73	-1.8109

Root Mean Square Percent Error = .0545

Turning Point Errors = 6. out of a possible 24

SIMULATION EX POST VARIABLE QACWS

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	983.00	1083.16	100.16	10.1890
1959	948.00	1074.67	126.67	13.3618
1960	1003.00	1080.22	77.22	7.6988
1961	1156.00	1120.67	-35.33	-3.0565
1962	1102.00	1111.39	9.39	.8517
1963	1115.00	1117.85	2.85	.2553
1964	1164.00	1115.74	-48.26	-4.1463
1965	1166.00	1126.00	-40.00	-3.4307
1966	1228.00	1191.03	-36.97	-3.0108
1967	1284.00	1231.16	-52.84	-4.1155
1968	1280.00	1330.19	50.19	3.9209
1969	1272.00	1457.56	185.56	14.5883
1970	1428.00	1470.44	42.44	2.9722
1971	1518.00	1523.97	5.97	.3934
1972	1652.00	1595.01	-56.99	-3.4499
1973	1678.00	1728.17	50.17	2.9897
1974	1859.00	1791.26	-67.74	-3.6441
1975	1655.00	1926.21	271.21	16.3876
1976	2054.00	1934.63	-119.37	-5.8115
1977	2047.00	2012.68	-34.32	-1.6766
1978	2079.00	2087.18	8.18	.3937
1979	2194.00	2245.63	51.63	2.3532
1980	2381.00	2467.89	86.89	3.6492
1981	2648.00	2570.61	-77.39	-2.9226
1982	2757.00	2567.80	-189.20	-6.8625

Root Mean Square Percent Error = .0650

Turning Point Errors = 6. out of a possible 24

SIMULATION EX POST VARIABLE QBRD

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	1289.00	1304.68	15.68	1.2164
1959	1257.00	1255.40	-1.60	-.1274
1960	1250.00	1215.14	-34.86	-2.7888
1961	1187.00	1174.95	-12.05	-1.0152
1962	1180.00	1139.28	-40.72	-3.4507
1963	1110.00	1105.85	-4.15	-.3741
1964	1117.00	1068.75	-48.25	-4.3193
1965	1102.00	1046.25	-55.75	-5.0590
1966	1048.00	1016.30	-31.70	-3.0251
1967	968.00	990.96	22.96	2.3724
1968	976.00	967.13	-8.87	-.9085
1969	915.00	949.30	34.30	3.7491
1970	893.00	932.79	39.79	4.4561
1971	868.00	920.52	52.52	6.0506
1972	858.00	908.55	50.55	5.8917
1973	837.00	900.03	63.03	7.5306
1974	908.00	925.46	17.46	1.9226
1975	935.00	921.88	-13.12	-1.4029
1976	925.00	889.75	-35.25	-3.8112
1977	855.00	883.08	28.08	3.2844
1978	891.00	882.63	-8.37	-.9391
1979	915.00	874.92	-40.08	-4.3805
1980	879.00	870.59	-8.41	-.9563
1981	874.00	870.29	-3.71	-.4246
1982	852.00	883.36	31.36	3.6811

Root Mean Square Percent Error = .0352

Turning Point Errors = 8. out of a possible 24

SIMULATION EX POST VARIABLE QBWS

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	1486.00	1405.73	-80.27	-5.4017
1959	1411.00	1381.20	-29.80	-2.1121
1960	1436.00	1405.68	-30.32	-2.1111
1961	1536.00	1443.11	-92.89	-6.0477
1962	1579.00	1452.49	-126.51	-8.0120
1963	1454.00	1401.25	-52.75	-3.6281
1964	1469.00	1420.49	-48.51	-3.3021
1965	1346.00	1381.15	35.15	2.6118
1966	1128.00	1314.49	186.49	16.5325
1967	1238.00	1307.18	69.18	5.5881
1968	1175.00	1323.70	148.70	12.6555
1969	1126.00	1324.76	198.76	17.6517
1970	1143.00	1275.58	132.58	11.5991
1971	1147.00	1244.91	97.91	8.5361
1972	1102.00	1192.35	90.35	8.1991
1973	919.00	1000.39	81.39	8.8562
1974	962.00	794.13	-167.87	-17.4503
1975	984.00	822.90	-161.10	-16.3718
1976	979.00	942.86	-36.14	-3.6920
1977	1086.00	1046.31	-39.69	-3.6550
1978	994.00	1058.96	64.96	6.5348
1979	985.00	1079.23	94.23	9.5669
1980	1145.00	1128.55	-16.45	-1.4365
1981	1228.00	1190.77	-37.23	-3.0320
1982	1257.00	1277.93	20.93	1.6648

Root Mean Square Percent Error = .0905

Turning Point Errors = 9. out of a possible 24

SIMULATION EX POST VARIABLE QFDRD

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	8494.00	8755.44	261.44	3.0779
1959	9102.00	9173.41	71.41	.7845
1960	9186.00	9394.79	208.79	2.2729
1961	9332.00	9239.51	-92.49	-.9911
1962	9482.00	9572.38	90.38	.9531
1963	9689.00	10011.40	322.45	3.3280
1964	10002.00	10288.70	286.67	2.8661
1965	10308.00	10395.10	87.05	.8445
1966	10232.00	9985.40	-246.60	-2.4101
1967	10259.00	10114.60	-144.41	-1.4076
1968	10698.00	10287.60	-410.35	-3.8358
1969	10753.00	10600.40	-152.64	-1.4196
1970	10753.00	10687.70	-65.28	-.6071
1971	10685.00	10827.90	142.94	1.3378
1972	10700.00	10933.30	233.27	2.1801
1973	10833.00	10614.30	-218.74	-2.0192
1974	10968.00	11404.20	436.19	3.9770
1975	11690.00	11812.70	122.74	1.0500
1976	11415.00	11306.30	-108.72	-.9524
1977	11499.00	11285.70	-213.32	-1.8551
1978	11536.00	11332.60	-203.41	-1.7633
1979	11471.00	11255.40	-215.62	-1.8797
1980	11684.00	11786.90	102.92	.8809
1981	11694.00	11840.30	146.33	1.2513
1982	11860.00	12004.80	144.82	1.2211

Root Mean Square Percent Error = .0204

Turning Point Errors = 7. out of a possible 24

SIMULATION EX POST VARIABLE QFDWS

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	8772.00	9033.44	261.44	2.9804
1959	9367.00	9438.40	71.41	.7623
1960	9453.00	9661.79	208.79	2.2087
1961	9560.00	9525.51	-34.49	-.3608
1962	9678.00	9894.37	216.38	2.2357
1963	9826.00	10394.40	568.45	5.7851
1964	10162.00	10648.70	486.67	4.7891
1965	10412.00	10815.00	403.05	3.8710
1966	9077.00	11692.40	2615.40	28.8135
1967	9257.00	11656.60	2399.59	25.9219
1968	10882.00	10665.60	-216.35	-1.9882
1969	10790.00	11114.40	324.36	3.0061
1970	10605.00	11411.70	806.72	7.6070
1971	10860.00	11228.90	368.94	3.3972
1972	10839.00	11298.30	459.27	4.2372
1973	10857.00	11066.30	209.26	1.9274
1974	10583.00	12229.20	1646.19	15.5551
1975	11802.00	12116.70	314.74	2.6668
1976	11513.00	11624.30	111.28	.9666
1977	11586.00	11614.70	28.68	.2475
1978	11599.00	11685.60	86.59	.7465
1979	11560.00	11582.40	22.38	.1936
1980	11661.00	12091.90	430.92	3.6954
1981	11669.00	12148.30	479.33	4.1077
1982	11763.00	12312.80	549.82	4.6742

Root Mean Square Percent Error = .0894

Turning Point Errors = 5. out of a possible 24

SIMULATION EX POST VARIABLE QFMRD

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	56453.00	57507.20	1054.21	1.8674
1959	56187.00	57175.30	988.32	1.7590
1960	56130.00	56707.00	576.98	1.0279
1961	54506.00	55993.00	1486.99	2.7281
1962	54964.00	55620.50	656.50	1.1944
1963	55464.00	55244.10	-219.94	-.3965
1964	55611.00	54557.30	-1053.67	-1.8947
1965	55628.00	54173.00	-1455.02	-2.6156
1966	55220.00	53332.30	-1887.75	-3.4186
1967	53527.00	52410.40	-1116.63	-2.0861
1968	52940.00	51689.60	-1250.36	-2.3618
1969	51762.00	51732.40	-29.59	-.0572
1970	50844.00	51414.00	569.97	1.1210
1971	50337.00	50861.60	524.61	1.0422
1972	51660.00	50513.60	-1146.43	-2.2192
1973	50680.00	49612.70	-1067.29	-2.1059
1974	48253.00	48672.00	419.03	.8684
1975	47623.00	49304.50	1681.53	3.5309
1976	48002.00	48183.20	181.20	.3775
1977	47880.00	47787.90	-92.12	-.1924
1978	47675.00	47941.80	266.82	.5597
1979	47886.00	47820.90	-65.08	-.1359
1980	47433.00	47667.20	234.16	.4937
1981	47025.00	47156.70	131.65	.2800
1982	45860.00	47237.40	1377.41	3.0035

Root Mean Square Percent Error = .0183

Turning Point Errors = 8. out of a possible 24

SIMULATION EX POST VARIABLE QFMWS

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	58600.00	59707.30	1107.26	1.8895
1959	58500.00	59547.90	1047.95	1.7914
1960	58600.00	59177.00	576.98	.9846
1961	57100.00	58587.00	1486.99	2.6042
1962	57719.00	58375.50	656.50	1.1374
1963	58366.00	58146.10	-219.94	-.3768
1964	58642.00	57756.90	-885.09	-1.5093
1965	58843.00	57388.00	-1455.02	-2.4727
1966	58531.00	56643.30	-1887.75	-3.2252
1967	56865.00	55748.40	-1116.63	-1.9637
1968	56316.00	55065.60	-1250.36	-2.2203
1969	55197.00	55167.40	-29.59	-.0536
1970	54306.00	54876.00	569.97	1.0496
1971	53831.00	54355.60	524.61	.9746
1972	55160.00	54013.60	-1146.43	-2.0784
1973	54180.00	53112.70	-1067.29	-1.9699
1974	51753.00	52172.00	419.03	.8097
1975	51123.00	52804.50	1681.53	3.2892
1976	51502.00	51683.20	181.20	.3518
1977	51380.00	51287.90	-92.12	-.1793
1978	51175.00	51441.80	266.82	.5214
1979	51386.00	51320.90	-65.08	-.1267
1980	50933.00	51167.20	234.16	.4597
1981	50525.00	50656.70	131.65	.2606
1982	49360.00	50737.40	1377.41	2.7905

Root Mean Square Percent Error = .0172

Turning Point Errors = 7. out of a possible 24

SIMULATION EX POST VARIABLE QNDMWD

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	818.00	850.63	32.63	3.9888
1959	941.00	885.63	-55.37	-5.8845
1960	999.00	899.97	-99.03	-9.9134
1961	957.00	887.95	-69.05	-7.2157
1962	940.00	912.04	-27.96	-2.9743
1963	922.00	924.97	2.97	.3217
1964	966.00	956.33	-9.67	-1.0013
1965	923.00	973.49	50.49	5.4700
1966	1005.00	950.27	-54.73	-5.4455
1967	977.00	987.33	10.33	1.0571
1968	1029.00	995.32	-33.68	-3.2730
1969	1031.00	992.77	-38.23	-3.7084
1970	953.00	982.39	29.39	3.0837
1971	953.00	974.47	21.47	2.2532
1972	848.00	986.39	138.39	16.3198
1973	1055.00	1041.65	-13.35	-1.2651
1974	838.00	849.08	11.08	1.3224
1975	667.00	600.84	-66.16	-9.9186
1976	743.00	714.49	-28.51	-3.8367
1977	698.00	722.76	24.76	3.5475
1978	639.00	698.76	59.76	9.3520
1979	691.00	648.62	-42.38	-6.1337
1980	631.00	645.30	14.30	2.2658
1981	549.00	526.88	-22.12	-4.0296
1982	559.00	556.53	-2.47	-.4418

Root Mean Square Percent Error = .0584

Turning Point Errors = 5. out of a possible 24

SIMULATION EX POST VARIABLE QNDMWS

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	1710.00	1766.55	56.55	3.3070
1959	1723.00	1725.42	2.42	.1405
1960	1819.00	1766.47	-52.53	-2.8878
1961	2020.00	1829.21	-190.79	-9.4450
1962	2230.00	1844.94	-385.06	-17.2671
1963	2106.00	2003.55	-102.45	-4.8649
1964	2177.00	2478.01	301.01	13.8267
1965	1989.00	2053.07	64.07	3.2215
1966	1580.00	1613.58	33.58	2.1252
1967	1679.00	1601.33	-77.67	-4.6260
1968	1594.00	1629.03	35.03	2.1975
1969	1452.00	1630.80	178.80	12.3139
1970	1444.00	1548.34	104.34	7.2261
1971	1418.00	1496.93	78.93	5.5662
1972	1223.00	1408.82	185.82	15.1938
1973	917.00	1086.98	169.98	18.5370
1974	1020.00	741.19	-278.81	-27.3348
1975	1001.00	789.42	-211.58	-21.1364
1976	926.00	990.53	64.53	6.9686
1977	1107.00	1163.97	56.97	5.1462
1978	920.00	1185.18	265.18	28.8234
1979	909.00	1219.17	310.17	34.1222
1980	1161.00	1301.85	140.85	12.1321
1981	1314.00	1406.16	92.16	7.0136
1982	1401.00	1552.28	151.28	10.7982

Root Mean Square Percent Error = .1421

Turning Point Errors = 7. out of a possible 24

SIMULATION EX POST VARIABLE QRM

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	123220.00	122890.00	-330.40	-.2681
1959	121989.00	120993.00	-996.20	-.8166
1960	123109.00	122170.00	-939.35	-.7630
1961	125707.00	125990.00	282.80	.2250
1962	126251.00	126417.00	165.58	.1311
1963	125202.00	123188.00	-2014.13	-1.6087
1964	126967.00	123834.00	-3132.76	-2.4674
1965	124180.00	121950.00	-2230.26	-1.7960
1966	119912.00	119304.00	-608.06	-.5071
1967	118732.00	119636.00	903.78	.7612
1968	117225.00	122648.00	5423.29	4.6264
1969	116108.00	123730.00	7621.73	6.5643
1970	117007.00	121793.00	4785.77	4.0902
1971	118566.00	123140.00	4574.19	3.8579
1972	120025.00	120780.00	755.47	.6294
1973	115491.00	118660.00	3169.10	2.7440
1974	115586.00	116361.00	774.55	.6701
1975	115398.00	115759.00	360.64	.3125
1976	120180.00	117892.00	-2287.75	-1.9036
1977	122654.00	121603.00	-1050.62	-.8566
1978	121461.00	121685.00	224.14	.1845
1979	123411.00	122047.00	-1363.59	-1.1049
1980	128525.00	124637.00	-3888.30	-3.0253
1981	132634.00	128366.00	-4268.10	-3.2180
1982	135795.00	133883.00	-1912.39	-1.4083

Root Mean Square Percent Error = .0242

Turning Point Errors = 5. out of a possible 24

SIMULATION EX POST VARIABLE SACC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	238.30	224.41	-13.89	-5.8283
1959	245.50	201.38	-44.12	-17.9730
1960	291.40	229.28	-62.12	-21.3194
1961	366.40	248.53	-117.87	-32.1690
1962	307.10	272.31	-34.79	-11.3278
1963	282.70	288.07	5.37	1.8983
1964	271.90	289.23	17.33	6.3748
1965	270.20	297.11	26.91	9.9610
1966	322.10	305.53	-16.57	-5.1447
1967	302.30	290.50	-11.80	-3.9022
1968	291.10	293.78	2.68	.9194
1969	264.40	296.50	32.10	12.1419
1970	252.70	301.38	48.68	19.2639
1971	235.60	299.41	63.81	27.0820
1972	269.30	311.22	41.92	15.5673
1973	289.90	366.85	76.95	26.5446
1974	419.80	402.79	-17.01	-4.0522
1975	305.70	382.51	76.81	25.1246
1976	409.80	348.06	-61.74	-15.0667
1977	361.50	342.53	-18.97	-5.2465
1978	349.10	353.77	4.67	1.3368
1979	403.70	351.44	-52.26	-12.9446
1980	422.80	332.07	-90.73	-21.4603
1981	373.80	346.57	-27.23	-7.2854
1982	334.70	360.98	26.28	7.8518

Root Mean Square Percent Error = .1550

Turning Point Errors = 9. out of a possible 24

SIMULATION EX POST VARIABLE SACG

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	10.70	130.27	119.57	1117.4500
1959	20.20	355.38	335.18	1659.2800
1960	.60	509.74	509.14	84856.4000
1961	53.50	685.49	631.99	1181.2800
1962	79.10	633.20	554.10	700.5060
1963	39.10	528.98	489.88	1252.9000
1964	24.40	384.25	359.85	1474.8100
1965	.30	227.25	226.95	75650.1000
1966	.20	163.37	163.17	81583.8000
1967	80.80	100.82	20.02	24.7734
1968	51.60	.00	-51.60	-100.0000
1969	1.10	.00	-1.10	-100.0000
1970	1.30	.00	-1.30	-100.0000
1971	6.10	.00	-6.10	-100.0000
1972	.20	.00	-.20	-100.0000
1973	.40	.00	-.40	-100.0000
1974	1.10	.00	-1.10	-100.0000
1975	2.00	.00	-2.00	-100.0000
1976	1.60	91.18	89.58	5598.6900
1977	60.50	92.43	31.93	52.7835
1978	29.70	96.15	66.45	223.7360
1979	2.80	236.05	233.25	8330.2800
1980	168.60	552.10	383.50	227.4590
1981	515.40	977.82	462.42	89.7202
1982	646.80	1166.94	520.14	80.4167

Root Mean Square Percent Error = 280.6420

Turning Point Errors = 13. out of a possible 24

SIMULATION EX POST VARIABLE SBC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	28.30	26.50	-1.80	-6.3501
1959	20.00	19.93	-.07	-.3483
1960	21.20	14.87	-6.33	-29.8606
1961	19.50	16.14	-3.36	-17.2553
1962	31.20	17.79	-13.41	-42.9853
1963	32.10	16.34	-15.76	-49.0891
1964	37.10	17.56	-19.54	-52.6665
1965	27.10	16.68	-10.42	-38.4401
1966	30.20	14.12	-16.08	-53.2381
1967	18.40	13.95	-4.45	-24.1913
1968	14.50	17.25	2.75	18.9685
1969	25.10	20.64	-4.46	-17.7794
1970	19.70	23.27	3.57	18.1160
1971	26.20	28.95	2.75	10.5053
1972	11.10	30.40	19.30	173.9110
1973	33.50	34.88	1.38	4.1111
1974	34.70	33.83	-.87	-2.5115
1975	5.80	25.16	19.36	333.8640
1976	28.00	27.48	-.52	-1.8537
1977	34.20	32.69	-1.51	-4.4105
1978	15.20	36.90	21.70	142.7310
1979	25.20	43.56	18.36	72.8463
1980	36.50	56.90	20.40	55.8909
1981	47.30	66.17	18.87	39.8966
1982	28.10	83.16	55.06	195.9300

Root Mean Square Percent Error = .9483

Turning Point Errors = 8. out of a possible 24

SIMULATION EX POST VARIABLE SBG

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	41.00	.00	-41.00	-100.0000
1959	11.00	.00	-11.00	-100.0000
1960	55.60	55.60	.00	.0076
1961	205.30	121.50	-83.80	-40.8201
1962	328.20	168.05	-160.15	-48.7959
1963	239.00	32.90	-206.10	-86.2350
1964	33.80	.00	-33.80	-100.0000
1965	25.00	72.78	47.78	191.1290
1966	2.10	272.53	270.43	12877.8000
1967	150.20	454.92	304.72	202.8780
1968	102.90	556.19	453.29	440.5160
1969	63.60	687.26	623.66	980.5930
1970	99.10	807.41	708.31	714.7430
1971	70.70	826.12	755.42	1068.4800
1972	96.40	874.47	778.07	807.1240
1973	22.80	827.35	804.55	3528.7400
1974	14.50	645.07	630.57	4348.7700
1975	5.00	471.75	466.75	9335.0800
1976	19.10	505.55	486.45	2546.8400
1977	150.70	568.56	417.86	277.2790
1978	191.80	660.68	468.88	244.4630
1979	152.60	759.33	606.73	397.5970
1980	268.20	892.95	624.75	232.9410
1981	381.90	986.16	604.26	158.2240
1982	454.70	997.73	543.03	119.4270

Root Mean Square Percent Error = 34.3394

Turning Point Errors = 10. out of a possible 24

SIMULATION EX POST VARIABLE SMEC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	3.80	3.60	-.20	-5.3781
1959	3.70	3.21	-.49	-13.3025
1960	4.20	3.32	-.88	-21.0571
1961	5.00	3.51	-1.49	-29.7634
1962	4.30	3.75	-.55	-12.8130
1963	4.10	3.83	-.27	-6.4716
1964	4.30	3.86	-.44	-10.1287
1965	3.90	3.90	.00	-.0206
1966	4.80	3.90	-.90	-18.6493
1967	4.30	3.77	-.53	-12.3120
1968	4.00	3.88	-.12	-2.9016
1969	3.80	3.98	.18	4.6621
1970	3.70	4.08	.38	10.3671
1971	3.60	4.22	.62	17.1157
1972	3.50	4.35	.85	24.3095
1973	4.70	5.02	.32	6.8009
1974	5.60	5.35	-.25	-4.5315
1975	3.70	4.89	1.19	32.2271
1976	5.30	4.67	-.63	-11.9582
1977	4.90	4.76	-.14	-2.8651
1978	4.50	4.97	.47	10.4298
1979	5.40	5.14	-.26	-4.8844
1980	5.80	5.35	-.45	-7.7282
1981	5.40	5.68	.28	5.2701
1982	4.60	6.23	1.63	35.3367

Root Mean Square Percent Error = .1561

Turning Point Errors = 9. out of a possible 24

SIMULATION EX POST   VARIABLE SNDMC

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	88.00	74.63	-13.37	-15.1915
1959	97.00	61.99	-35.01	-36.0892
1960	103.10	48.30	-54.80	-53.1508
1961	132.50	45.88	-86.62	-65.3727
1962	99.00	40.50	-58.50	-59.0940
1963	81.50	30.97	-50.53	-62.0043
1964	108.80	28.65	-80.15	-73.6707
1965	58.20	22.23	-35.97	-61.7983
1966	118.20	16.44	-101.76	-86.0905
1967	98.70	18.85	-79.85	-80.8993
1968	79.00	23.34	-55.66	-70.4550
1969	83.90	22.05	-61.85	-73.7236
1970	95.30	24.02	-71.28	-74.7965
1971	77.00	34.18	-42.82	-55.6066
1972	37.90	32.66	-5.24	-13.8238
1973	74.50	54.54	-19.96	-26.7958
1974	134.60	61.27	-73.33	-54.4812
1975	47.10	32.69	-14.41	-30.6038
1976	98.80	46.37	-52.43	-53.0693
1977	60.70	57.68	-3.02	-4.9707
1978	40.10	63.63	23.53	58.6788
1979	92.60	79.50	-13.10	-14.1503
1980	85.00	116.77	31.77	37.3749
1981	86.70	117.72	31.02	35.7837
1982	93.30	133.97	40.67	43.5916

Root Mean Square Percent Error =   .5445

Turning Point Errors = 11. out of a possible 24

SIMULATION EX POST   VARIABLE SNDMG

	ACTUAL	PREDICTED	ABS ERROR	PER ERROR
1958	155.00	192.29	37.29	24.0575
1959	60.00	175.72	115.72	192.8690
1960	279.80	462.92	183.12	65.4464
1961	354.90	447.61	92.71	26.1215
1962	576.00	283.89	-292.11	-50.7134
1963	404.60	.00	-404.60	-100.0000
1964	65.50	.00	-65.50	-100.0000
1965	96.20	.00	-96.20	-100.0000
1966	.00	58.10	58.10	99999.9000
1967	157.60	106.69	-50.91	-32.3045
1968	198.70	192.91	-5.79	-2.9157
1969	137.80	355.23	217.43	157.7880
1970	42.60	344.22	301.62	708.0190
1971	12.50	343.51	331.01	2648.0600
1972	6.90	347.46	340.56	4935.6200
1973	.10	538.91	538.81	**********
1974	158.60	461.28	302.68	190.8480
1975	421.80	519.45	97.65	23.1505
1976	386.60	614.80	228.20	59.0282
1977	617.20	827.69	210.49	34.1047
1978	545.00	934.16	389.16	71.4061
1979	392.70	1171.85	779.15	198.4090
1980	501.70	1389.14	887.44	176.8860
1981	803.00	1833.46	1030.46	128.3260
1982	1188.70	2361.27	1172.57	98.6427

Root Mean Square Percent Error =**********

Turning Point Errors = 11. out of a possible 24