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Price Supports, Risk Aversion and U.S. Dairy Policy: An Alternative Perspective of the Long-Term Impacts

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PRICE SUPPORTS, RISK AVERSION AND U.S. DAIRY POLICY: AN ALTERNATIVE PERSPECTIVE OF THE LONG-TERM IMPACTS

by Cameron S. Thraen and Jerome W. Hammond*

I. INTRODUCTION

Background

The federal dairy price-support program has provided producers with minimum prices for over three decades. Operation of this program has necessitated the purchase of billions of pounds of milk in the form of cheese, butter and nonfat dry milk. The cost of the program has accounted for a large proportion of total costs of price support for farm commodities. Additionally there has been the problem of disposing of government acquired dairy products in outlets that do not displace commercial dairy product sales. Consequently, the program has periodically faced proposals for revision or its complete elimination. The current record levels of purchases have again generated a number of such proposals.

A key question with regard to dairy price supports is, how would the industry have performed over the long-run with alternative levels of support or with no price supports? This question is somewhat different than asking what would happen this year if price supports were simply dropped. If price supports are currently effective, the long-run effect of dropping or reducing them may be considerably different from the immediate effect of the change.

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Economists and public policy analysts have been concerned about long-run farm price support impacts for many years. Herdt and Cochrane(1967) suggested that a combination of rapid technological advance and guaranteed minimum prices have created strong economic incentives for producer to increase their rate of capital investment. The mechanism by which guaranteed minimum prices have altered the behavior of agricultural producers is described by Lyle Schertz (1979):

> "Because of government support prices, with an effective 'floor', . . . reduced risks and uncertainty enhance the willingness of farmers to invest, adopt new technology and increase output. Income supplements through . . . support prices . . . facilitate increased output . . . by affecting the (1) actual cash flow of farmers, and (2) longer-run expectations of the average profitability of investment in farming on the part of farmers and farm creditors."

In response to these general concerns a number of studies have been conducted and reported in the economics literature which have attempted to measure the impact of the dairy price-support program on the economic performance of the dairy industry (Heien, 1977; Dahlgran, 1980 and Hallberg, 1981). Generally, the conclusions drawn from these models have one or more of the following characteristics: (i) static profit maximization is the central economic rationalization, (ii) dynamic adjustments are introduced by use of "ad hoc" specification of a partial adjustment model or some variation of this type of model, (iii) price-support policy is introduced as either a dummy variable or as the absolute level of support and (iv) producers' subjective expectations of future prices is totally absent. The impact of the price-support program is then estimated by restricting the support price or governmental purchases to zero and solving the estimated aggregate model for the implied market equilibrium on prices, production and consumption.

Recent developments in the theory of firm behavior under uncertainty and in the theory and econometric modeling of policy analysis raise questions as to the accuracy of the conclusions reached in these studies (Fisher, 1982 and Epstein, 1978). The development of an econometric model to assess the influence of the dairy price support policy on the economic performance of the dairy sector should incorporate these theoretical developments. Just(1982) demonstrated that producers reaction to changing risk levels brought about by government intervention in free market systems can be significant. Models which do not account for this can provide substantially biased conclusions. In addition the dynamic elements of the economic problem should be developed within the optimizing structure of the basic model and should not rely on the ad hoc specification of simple partial adjustment models, as argued by Nerlove (1979). Furthermore, as Lucas(1976) has argued producers' expectations of the future levels of economic variables directly influence their decision today. Lucas' thesis is that economic agents, in this case dairy producers, make production and input decisions based on their knowledge of the parameters implicit in government policies affecting their enterprise's profitability. Changes in this policy also result in changes in the parameters of the econometric model. Policy analysis should explicitly define the relationship between changes in policy parameters and those of the econoetric model used for analysis.

Objectives

The objective of this study is to evaluate, for the U.S. dairy economy, the impact of alternative price support policies on the levels of domestic milk production, consumption and market price over the time period 1950-78. Assessment of alternative policies, which might have been followed, or may be pursued into the 1980's requires the extension of current dairy models. A model of the dairy industry will be developed that explicitly recognizes the elements of risk aversion and the role of rational producer expectations in production decisions.

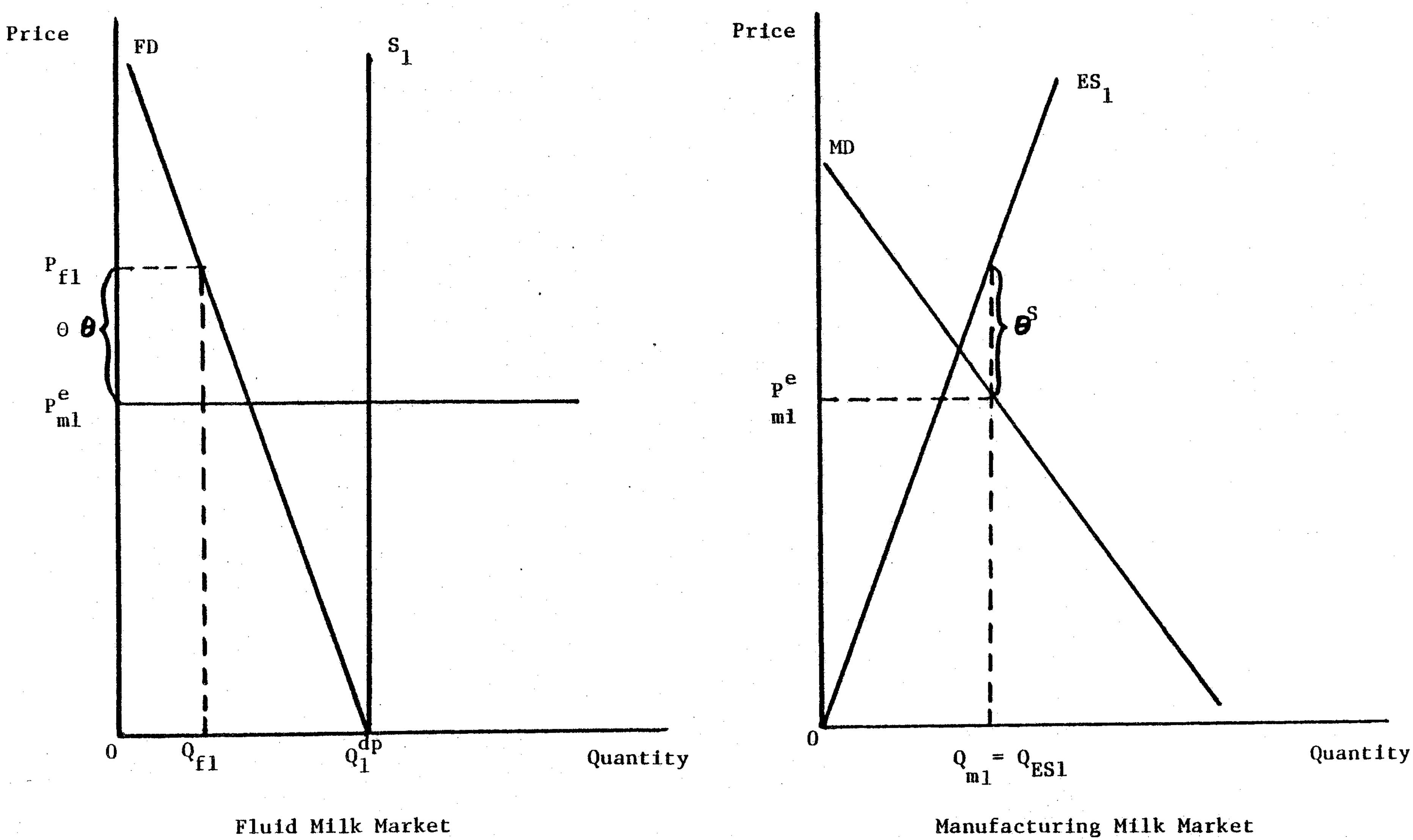
II. THE ECONOMETRIC MODEL OF THE INDUSTRY

The model for analysis of price support impacts is developed and statistical estimates of that model are presented in this chapter. It is a supply-demand model that reflects the pricing mechanisims that have been applied under both the federal milk order program (and similar state programs) and the milk price support program for the period 1049-1978.

A Graphical Representation of the Dairy Economy

Basic Features of Model A simplified graphical model illustrates the basic components of the U.S. dairy economy. Because an administrative two price system is applied to the dairy industry under the federal milk order program, this feature must be included in the model. This program and similar state programs fix different prices in the fluid milk and the manufacturing milk market. Such a model is illustrated graphically on Figure 1a. The fluid milk market demand, FD, represented here is the aggregation of many local markets which exist for each major milkshed in the U.S. The manufacturing market, MD, is the aggregate national market for milk used in manufactured dairy products. The slopes of the respective demand curves reflect a more inelastic fluid demand than manufacturing demand. Total domestic production of all milk Q_1^{dp} is taken as predetermined and to be a function of both supply price and demand shifters.[1/]

Figure 1a. Equilibrium Between Fluid and Manufacturing Milk Markets.



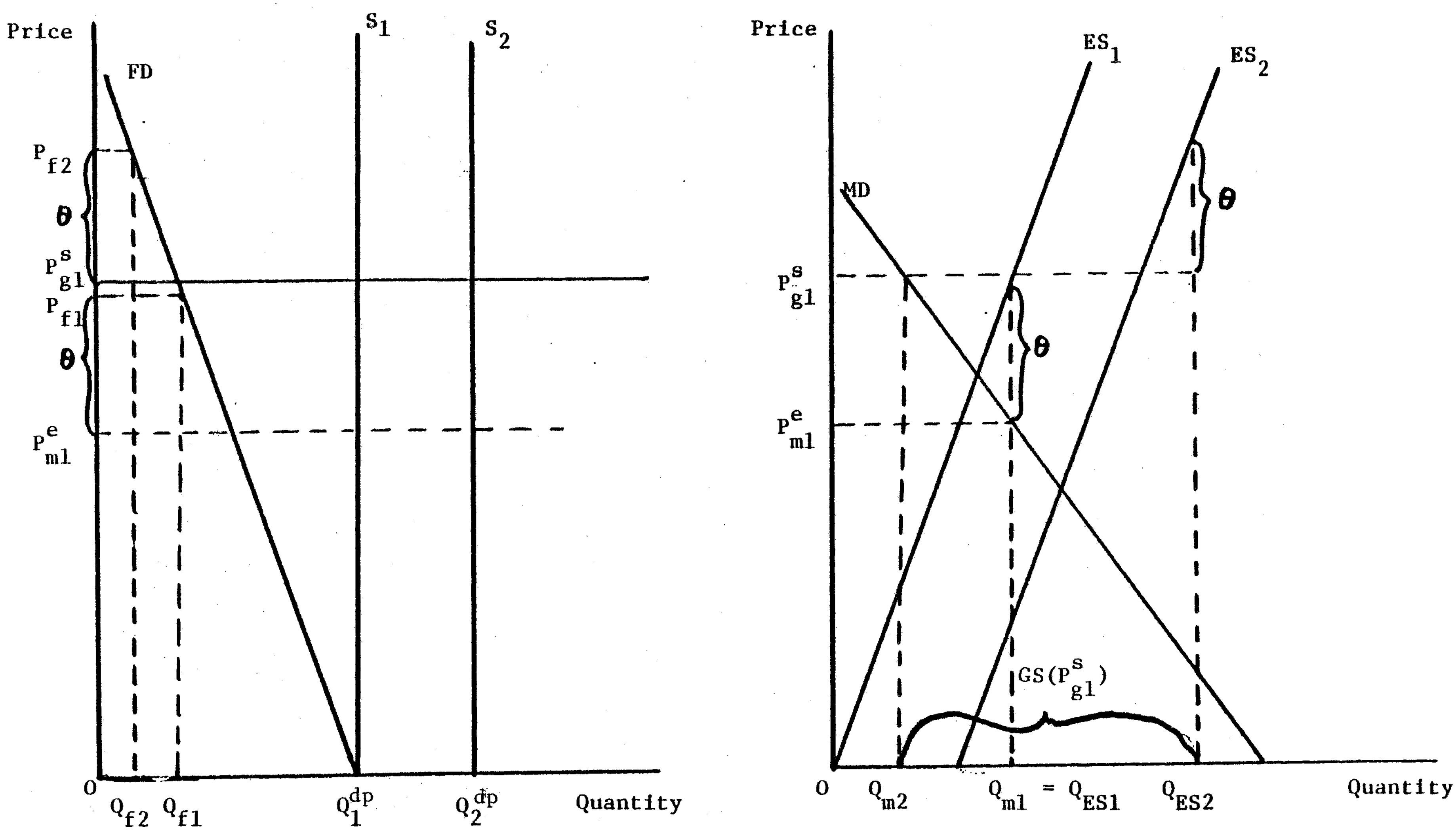
We must now introduce an additional variable, the fluid-manufacturing price differential. The federal milk marketing order program specifies that fluid prices must be higher than manufacturing prices by a differential defined here as θ. This merely represents an additional charge to the fluid milk market. Such a charge raises the market price for fluid milk and depresses the market price for manufacturing milk by shifting milk from the fluid to manufacturing markets. The effect on competetive equilibrium is to reduce quantity of fluid demanded somewhat and to increase quantities supplied and demanded of manufactured dairy products. The precise effects depends on the relative slopes of the demand curves.

Supply available to the manufacturing market is the excess supply from the fluid milk market. Because the fluid milk price is higher than the manufacturing milk price, fluid demand should be satisfied first. Any residual supply is then available to be transformed into manufactured dairy products. The manufacturing supply is illustrated as ES in the manufacturing market, and is calculated by subtracting the quantity of fluid milk consumed at any price from the available supply of milk. A competitive market equilibrium is achieved by the equating of excess demand, here taken as MD, with excess supply, ES_1. Such an equilibrium, with the federal order differential equal to θ, is depicted in Figure 1a. The equilibrium manufacturing price is P^e_{m1}, manufacturing quantity consumed is Q_{m1}, the fluid price is $P_{f1} = P^e_{m1} + \theta$ and the fluid use is Q_{f1}.

Equilibrium with Price Support Using the framework of the aggregate model represented in Figure 1a, let us introduce a price-support policy, which establishes a floor for manufacturing milk prices. When effective, the minimum price P^s_{g1} is such that $P^s_{g1} > P^e_{m1}$. The economic effect on production, consumption, market price and government stocks of this price-support policy illustrated in figure 1b. The price increase and a reduction in perceived risk causes producers to increase aggregate capital stock and thus the level of milk production. This can be represented by a shift in production from Q_1^{dp} to Q_2^{dp}. Assuming that demand and other economic factors are held constant, the effect of the price-support is to increase the quantity of excess milk available to supply the manufacturing market. This is depicted by shifting the excess supply curve ES_1 to ES_2. The additional supply on the manufacturing market would normally result in a decline in P_m^e and P_f and increases in quantity of fluid and manufacturing milk use. This does not occur because the price in the manufacturing market is fixed at P_{g1}^s. Manufacturing demand responds to the new fixed market price P_{g1}^s with quantity Q_{m2}. The fluid price is now $P_{f2}^s = P_{g1}^s + \theta$, thus, fluid demand declines to Q_{m2}. From this we can determine the quantity of manufactured products the federal authorities will have to purchase to maintain the support price. The difference between the total excess supply and manufactured demand, $QES_2 - Q_{m2}$ is the quantity of government support purchases, $GS(P_{g1}^s)$.

This aggregate model can be usefully employed as an aid in providing a clearer understanding of the dynamic change which would occur as we change the level of price supports over time. Consider the following example of a gradual decline in price-support level, illustrated in Figure 1c. In this example, assume that the positions of FD and MD do not change with the shift of price support P_g^s and total milk production Q^{dp}. In Figure 1c, the initial price support is identical to that illustrated in Figure 1b. Consider this solution to the model as representing an

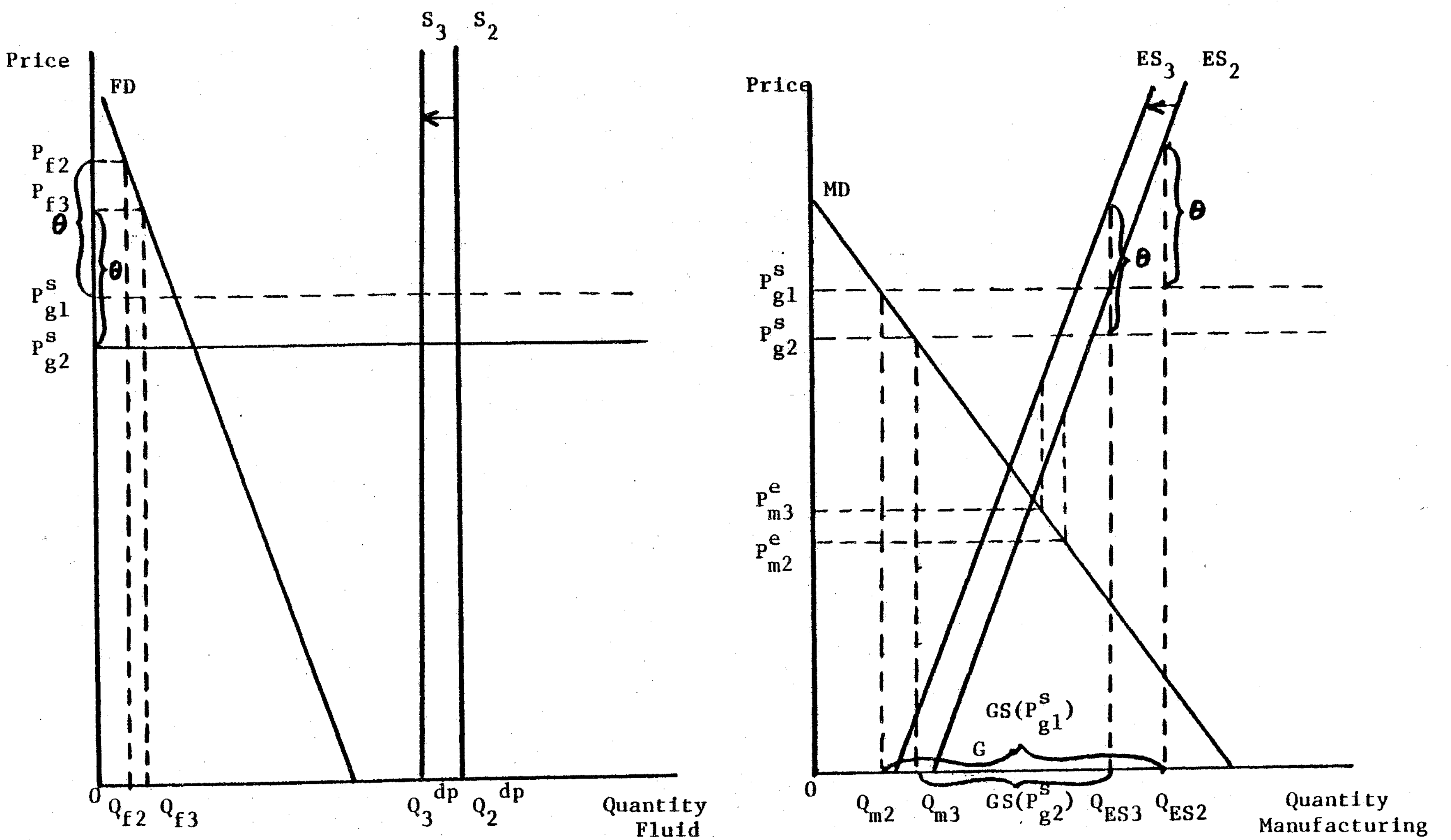
Figure 1b. Economic Impact of a Price-Support on Dairy Market Price, Production and Demands.



Fluid Milk Market

Manufacturing Milk Market

Figure 1c. Economic Impact of a Shift in the Level of Price-Support on the Equilibrium of the Dairy Market.



initial base year t_o. The next year t_1, price-support is set at a lower level. Given those conditions, what, then will prevail as the market clearing price — the new support level P^s_{g2} or a market generated equilibrium price P^e_m?

This adjustment to a new price support level is illustrated in Figure 1c. Let the new level of price-support be established at P^s_{g2}, somewhat lower than P^s_{g1}. The impact on equilibrium values of prices and market demands depends crucially on the magnitude of the shift in total supply and the initial equilibrium in period t_o. Suppose that supply shifts to position S_3 in Figure 1c. As will be argued later, this shift comes about because of a decline in producers expected price and simultaneous increase in subjective risk. This shift decreases the supply of milk available to the manufactuturing milk market. This is illustrated by a shift in excess supply ES_3. The new equilibrium is represented by a lower manufacturing price, which is the support-price P^s_{g2}, manufacturing use of Q_{m3} and fluid milk price of P_{f3} and a smaller quantity of price-support purchases, $GS(P^s_{g2})$.

Now consider the bahavior of the non-support equilibrium price P^e_m in the manufacturing market. It is, as expected, nearer to the support-price than in period t_o. The decline in price support resulted in a total supply change and a subsequent shift of excess supply that increased P^e_{m2} to $P^{e'}_{m3}$. It is apparent that the support-price and the market equilibrium price have moved closer together. The rate at which these two points move together depends upon four factors: (1) the amount by which P^s_g declines over time, (2) the marginal effect of P^s_g on total supply - the greater the response the more rapid the adjustment to P^e_m; (3) the marginal impact of increased risk on production, and (4) the elasticity of MD - the rate of convergence increases as MD becomes more inelastic. Another very important point to keep in mind regarding this model is the ceteris paribs assumption for other variables in the systems. If, for example, an exogenous variable were allowed to change along with the change in price support level; it would produce a reinforcing or offsetting shift in either production or the demand curve. The effect would either increase or slow the rate of adjustment.

Finally, it is necessary to consider what this structural formulation of the interlinkage of prices, support prices, production and demand implies in the long-term for market equilibrium prices. Considering figure 1c, a number of points can be addressed. First, if the support price level is substantially greater than the current market clearing equilibrium price, and support prices are lowered gradually, it could conceivably take many years to bring about an adjustment which would establish a free market clearing price; ceteris paribus. Clearly, this depends on the degree of inelasticity of manufacturing demand and the marginal responsiveness of dairy producers to changes in price-support levels and increases in perceived risk. Second, the question naturally arises as to whether or not the new long-term prices could be higher without price supports, or at least with lower support levels, than would prevail with support unaltered as to level. In a dynamic economic system, that could be the situation. Whether or not it occurs depends upon (i) the position of the price support levels relative to the equilibrium clearing prices, (ii) the rate at which the support price is reduced, (iii) the marginal sensitivity of producers to lower levels of price support, and (iv) the marginal sensitivity of producers to increased levels of risk, either actual or perceived.

This model forms the basis for specifying the basic market level equations of an econometric model for evaluation of alternative price support policies. It provides insights into the functioning of the dairy economy and a basis for integrating producers aggregate investment and production decisions and the determination of prices, consumption and government stocks into the econometric model.

The Mathematical Form of the Model

The econometric model of the diary industry is an aggregate supply-demand model of the industry. The equations for the production sector were derived by solving the firm-level demand for capital. It was assumed that the firm is a risk averse expected utility maximizer and chooses input levels for quasi-fixed inputs subject to increasing costs of capital adjustment. Producer expectations on endogenous and/or exogenous variables were replaced by the rational expectations of those variables. The demand functions were based on traditional considerations and specified as such. All equations are linear in variables and the parameter estimates are by single equation methods.

Domestic Milk Production Equations The specifications of annual production of milk are:

(1) $KC_t = h_1(KC_{t-1}, PB^*_t, CP^*_t, PCAIR^*_t, RRI_{t-1}, U_{1t}),$

(2) $PB^*_t = E_{t-1} (PB_t \mid \Omega_{t-1}),$

(3) $CP^*_t = E_{t-1} (CP_t \mid \Omega_{t-1}),$

(4) $PCAIR^*_t = E_{t-1} (PCAIR_t \mid \Omega_{t-1}),$

(5) $Q^{dp}_t = h_2(KC_t, U_{2t}).$

Where KC_t is the adjusted animal units in the U.S. dairy herd at the beginning of period t; PB_t^* is the expected market clearing price for all milk at period t, conditioned on all available information at t-1, Ω_{t-1}; CP_t^* is the expected cull cow price in period t, conditioned on the information set Ω_{t-1}; $PCAIR^*$ is the expected interest rate (cost of capital) in period t, conditioned on the information set Ω_{t-1}; RRI_{t-1} is a variance based proxy measure of the relative "riskiness" of dairy prices to crop returns in period t-1; Q_t^{dp} is annual domestic milk production in period t; U_{it} are stochastic error terms, i = 1, 2.

Fluid, Manufacturing and Commercial Stock Demand Equations Farm level demand functions for fluid milk and manufactured dairy products (milk equivalent-fats basis) and ending commercial stocks were specified as:

(6) $FD_t = h_3(P_{ft}, PFS_t, RDII_t, U3_t)$

(7) $MD_t = h_4(P_{mt}, PFOS_t, RDII_t, U_4t)$

(8) $ECS_t = h_5(O_t^{dp}, P_{gt}^s, P_{gt-1}^s, PFS_t, U_{5t})$.

Where FD_t is fluid demand in period t; P_ft is fluid milk price in t; PFS_t is a price index of fluid milk substitutes in t; $RDII_t$ is an index of real disposable income in t; MD_t is the demand for manufacturing milk in t; P_{mt} is the market clearing manufacturing milk price in t; P_{gt}^s is the support price is to, $PFOS_t$ is the price index of dairy product substitutes (non-dairy fats and oils) in t; ECS_t is ending commercial stocks in t; U_{it} are stochastic error terms, i = 3, 4, 5.

The Equilibrium Condition This equilibrium condition is specified as:

(9) $$MS_t = Q_t^{dp} + NBS_t = FD_t - FU_t - ECS_t = MD_t.$$

Where MS_t is the total manufacturing supply of milk in t; NBS_t is net imports plus beginning commercial stocks in t; and FU_t is farm-use of milk in t.

Producer Blend, Fluid and Manufacturing Use Prices To complete the model specification, fluid prices need to be linked to manufacturing prices so that the producers blend price can be determined. The average price paid to producers in the U.S. dairy market is represented by the blend price PB_t. This is a utilization weighted average of the fluid price PF and the manufacturing price PM which can be expressed as:

(10) $$PB_t = P_{mt} + \Theta_t \gamma_t$$

where Θ_t is the government set Class I price differential, and γ_t is the fluid utilization rate in period t.

The fluid price is specified as:

(11) $$P_{ft} = P_{mt} + \Theta_t.$$

The equilibrium solution to this model was derived by substituting equations (1), (6), (7) and (8) into the supply-demand identity (9), and making use of the price identities (10), and (11) to replace PB_t and P_{ft}; solving for the manufacturing market price P_{mt} which satisfies the the equilibrium condition:

(12) $$P_{mt} = h_6(KC_{t-1}, P^s_{gt}, P^s_{gt-1}, CP^*_t, PCAIR^*_t, RRI_{t-1}, RDII_t, PFS_t, PFOS_t, NBS_t, FU_t, V_t)$$

Where V_t is a stochastic composite error term. Given a parametric specification for the function h_6 and values for the determining variables on the right hand side of (12), this price P_{mt} will determine a unique production, consumption and price set. In the event that this equilibrium market price is lower than the exogenous support-price for the period, then the model solution is determined by setting market price equal to support price and solving for the appropriate levels of fluid and manufacturing demand and the quantity of excess supply.

Implications of Rational Expectations for the Model Notice also that if we consider the conceptual model listed in equations (1) through (11) as the structural model for the dairy economy, then the explanatory variables on the right hand side of the equilibrium market price solution (12) would be the set of variables contained in Ω_{t-1} in equation (2). This is one of the more striking features of the rational expectations hypothesis (REH). In the simple adaptive expectations models the expected price in the supply equation results in a distributed lag on past prices only. Under the assumption of REH rational expectations, we substitute the explicit form of the equilibrium solution for market price into (1) and then substitute (1) into (5) which results in domestic production being determined by all of the exogenous variables in both the supply and demand equations, but not market price P_{mt}.

Construction of Selected Variables

The final form of the econometric model used for the policy evaluation was arrived at after pretesting for included variable specification and functional form. Several variables which appeared on the right hand sides of the conceptual equations (1) through (8) were deleted after pretesting. Because of the limited number of annual observations in the data base 1949-1978, the number of explanatory variables was maintained as small as possible while still achieving a satisfactory degree of statistical validity and conceptual consistency. In addition the empirical specification of certain variables requires clarification.

Capital Stock Conceptually, it is possible to simply specify the capital stock variable, KC, of equation (5) as some measure of the total capital input used in the production of milk; either on an individual dairy farm or in aggregate. Empirically defining such a variable is not, however, as easily accomplished. Specifying dairy capital as equivalent to the number of producing cows at any point in time neglects both the genetic improvement in dairy animals as well as the influence on production brought about by changes in the quality and quantity of other capital (physical and human) and feed inputs. Genetic research and improved breeding practices have resulted in a steady increase in animal productivity. Thus, replacement animals are superior milk producers given the same bundle of other inputs (capital and variable) than their predecessors.[2/]

Using reported cow numbers as a proxy for aggregate capital with changing productivity complicates the problem of specifying the relationship between total dairy capital stock and total production. To adjust for changes in technology, the capital variable used in this study was formulated to reflect the relationship between production and animal units which would exist if yield per cow had not increased over the data period. This is given by:

(13) $KC_t = (Y_t \mid Y_0) \times K_t$ for all t,

where Y_t is per-cow yield in period t, Y_0 is the yield in an a base production year. The variable KC_t approximates the number of dairy animals in any given year which would have been required to produce the realized level of production with base year per cow productivity.[3/]

Risk Specification The empirical specification of the risk variable RRI_{t-1} in equation (1) requires that we provide proxy measures for the risk facing dairy producers. Market price is conceptually defined as the degree of precision of the producers subjective probability distribution on market price. The less precision (i.e., more variance) with respect to the subjective probabilfty distribution, the more likely it is that the actual realization of market price will deviate from the producers expectation and the larger the error will be.

Empirical risk specification has been traditionally handled by utilizing some form of a weighted deviation of past prices from an average mean price. In a recent article, Young (1980) defines specific criteria which he argues should be met by any objectively formulated measure of risk.

These criteria are:

(i) The variability measure should be conceptualized as the appropriately weighted mean square forecast error from a series of one-step ahead forecasts.

(ii) The relevant information set Ω should contain only information available at the time the expectation is formed.

(iii) The number of periods from which past information is drawn should be restricted to a limited number.

(iv) More recent information should be given more weight than more distant information in computing the risk measure.

(v) Both the risk measure and the expectation component should be updated frequently in the light of new information available.

(vi) The expectation process should be subject to revision in response to new information.

(vii) The functional expression for the expectations formulation and the risk measure should be explicit and sufficiently simple to be plausible as a subjective expectations formulation process.4/

With these criteria in mind, the specification of the risk variables in this study are:

(14) $$RRI_t = B_t / Z_t,$$

(15) $$Bt = PB_{t-1} / DPR_{t-1}$$

(16) $$Z_t = ACR_{t-1} / CRR_{t-1},$$

(17) $$DPR_{t-1} = \{\Sigma_{i=1}^{3} (PB_{t-i} - \overline{\overline{PB}}_{t-i})^2 \alpha_i\} / \overline{\overline{PB}}_{t-1};\ \alpha_1 = \frac{1}{2},\ \alpha_2 = \frac{1}{3},\ \alpha_3 = \frac{1}{6},$$

(18) $$\overline{\overline{PB}}_{t-1} = 1/3\ \Sigma_{i=1}^{3} PB_{t-i},$$

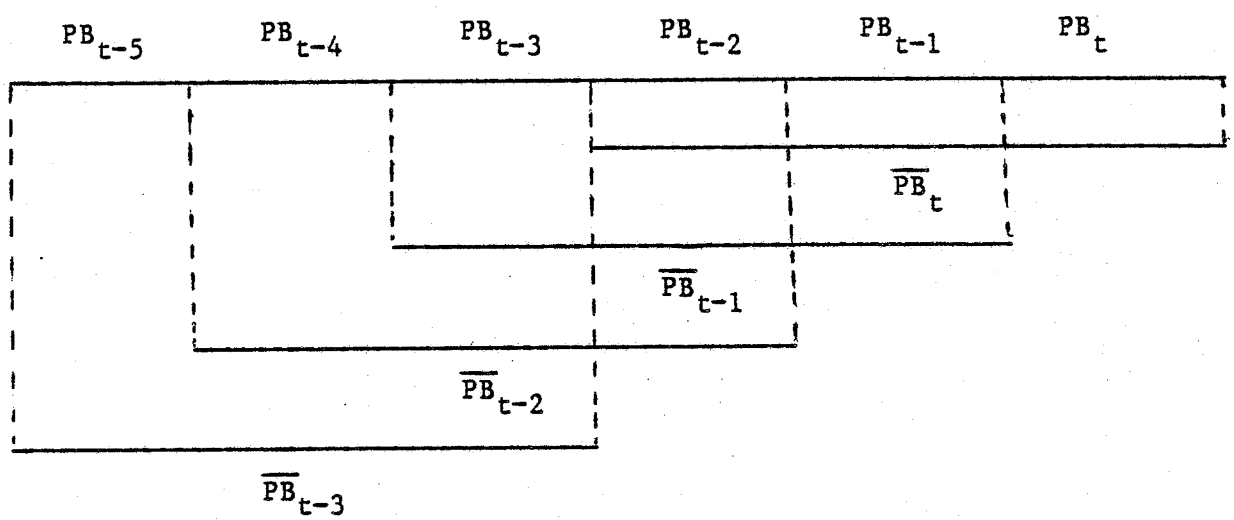
(19) $$CRR_{t-1} = \{\Sigma_{i=1}^{3} (ACR_{t-i} - \overline{\overline{\overline{ACR}}}_{t-i})^2 \gamma_i\} / \overline{\overline{\overline{ACR}}}_{t-1};\ \gamma_1 = \frac{1}{2},\ \gamma_2 = \frac{1}{3},\ \gamma_3 = \frac{1}{6},$$

(20) $$\overline{\overline{\overline{ACR}}}_t = 1/3\ \Sigma_{i=1}^{3} ACR_{t-i}$$

RRI_{t-1} is a measure of the relative instability of dairy prices to crop returns, B_{t-1} is the ratio of dairy price in period t-1 to dairy price instability in period t-1; Zt-1 is the ratio of gross returns to crop production in period t-1 to crop returns instability in period t-1; DPR_{t-1} and CRR_{t-1} are variance based proxies for instability in dairy prices and crop returns respectively; $\overline{\overline{PB}}_{t-1}$ and $\overline{\overline{ACR}}_{t-1}$ are three period moving averages for dairy blend prices and annual crop returns, respectively.

The structure of the price variable used in the risk variable is illustrated in Figure 2.

Figure 2: Structure of Prices Used in Risk Variable



In the diagram, the horizontal axis replicates production periods from t-5 through t. Each period has a realized market price entry Pt-i. The average prices given by equation (18) are represented by $\overline{\overline{PB}}_{t-3}$, $\overline{\overline{PB}}_{t-2}$, $\overline{\overline{PB}}_{t-1}$, $\overline{\overline{PB}}_t$ and form a moving average price series. This series establishes a trend component to past price movements. Taking an individual term from (17), for example $1/2(PB_{t-1} - \overline{\overline{PB}}_{t-2})^2$, we can see that this represents the weighted squared deviation of the most recently observed market price from the last computed trend price $\overline{\overline{PB}}_{t-2}$. The total variance is then the weighted sum of the last three such squared deviations. This total variation is then divided by the most recent average price $\overline{\overline{PB}}_{t-1}$ so as to free the measure from the absolute level of price. A single risk variable was computed as the ratio of dairy risk to crop risk, i.e., RRI_{t-1}.

Our formulation of the risk variable satisfies some, but not all, of the criterion listed by Young.[5/] The measure is not entirely consistent with the first criterion. We have chosen to focus on the expected market price and to assume that past history of market prices serves to capture the "riskiness" of the dairy economy. The formulation uses only information which is known up to the time that the expectations are formed in keeping with criterion two. Criteria three through seven seem to be reasonably met by this measure.

In summary the risk variable RRI_t increases as dairy price variability decreases relative to the variability of crop returns. This should have a positive effect on the variable KC_t.

<u>Expected Market Price</u> In order to specify an observable variable for the expected market price in equation (1), we must first specify an appropriate expectations model. Although adaptive expectations have been the mainstay of expectations models in applied agricultural models, we have selected the more appealing rational expectations model for our purposes. Rational expectations implies much richer economic content than does the adaptive models which exclude, a priori, a substantial amount of information from being used by producers in the formulation of price

expectations. For an economic model such as that detailed in equation (1) through (11), the rationally expected market price is given by taking expectations on both sides of equation (12):

$$(21) \qquad E(P^{*}_{mt}) = E_{t-1}\{h(KCt-1, P^{s}_{gt}, P^{s}_{gt-1}, CP_{t-1}, PCAIR_{t-1}, RRI_{t-1}, RDII_{t}, PFS_{t}, PFOS_{t}, NBS_{t}, FU_{t}, V_{t})$$

The expectation of already known variables such as KC(t-1) is trivial. The exectations of current variables such as P^{s}_{gt} can be modelled in a number of ways. In this study, it is taken that these expectations are formed as statistically optimal one-step-ahead forecasts. In equation (21) each variable with a current subscript is replaced by the expectation of the first-order autoregressive process; generally stated as:

$$(22) \qquad X_{it} = \phi X_{it-1} + \varepsilon_{t}$$

where ε_{t} is a white-noise process independent of the error structure in the underlying econometric model. In this case the expectation of the unknown independent variables are given by:

$$(23) \qquad E_{t-1}(X_{it} \mid \Omega_{t-1}) = \phi X_{it-1}.$$

Estimation of the Model

Statistical Estimation of the Structural Equations The data use for statistical estimation of the model were obtained from statistical reports of the U.S. Department of Agriculture and the U.S. Bureau of Labor Statistics. Some of these data were direct measures of the variables in the model. For other variables the data were used to construct the variables described in the preceding sections. These variables and the units of measure are:

Q_t^{dp} = U.S. annual domestic milk production, (million lbs.),

KC_t = U.S. annual dairy capital capacity index, (1,000's),

P_{gt}^s = U.S. annual Federal Dairy Price support (cents per cwt.),

RRI_t = Index of relative dairy "riskiness",

FD_t = U.S. annual fluid milk consumption, (million lbs.),

MD_t = U.S. annual manufacturing milk consumption, (million lbs.),

$RDII_t$ = U.S. real disposable income index, 1967-100,

PFS_t = U.S. retail food Price index-beverages, nondairy, 1967-100,

$PFOS_t$ = U.S. retail food price index-fats and oils, nondairy, 1967-100,

Θ = U.S. annual average class I price differential (cents per cwt.)

ACR_t = U.S. annual cash returns to crop production-all crops (millions of \$),

K_t = U.S. dairy cow inventory, Heifers > 2 years kept for milk, January 1, (1,000's of Animal Units),

P_{ft} = Fluid use milk price, (cents per cwt.),

P_{mt} = Manufacturing use milk price, (cents per cwt.)

CP_t = Slaughter cow price (\$ per cwt.)

ECS_t = U.S. Annual ending commercial stocks-milk equivalent, (millions of lbs.), and

FU_t = U.S. Annual farm-use milk, (millions of lbs.).

Their annual values for 1949-78 are listed in Table 1.

Both production and demand equations were astimated by the use of ordinary least-squares (OLS)[6/]. The Cochrane-Orcutt data transformation procedure was used to correct for serial correlation when present. The OLS technique is not inconsistent with the simultaneous equilibrium which exists between fluid demand, fluid price, manufacturing demand and manufacturing price when the manufacturing supply and demand are in equilibrium above the support price level. Because the federal dairy price support program has purchased manufactured dairy products to support the market price in each year with the exception of one, from 1949 through 1978, the market equilibrium price is below the mandated support-price. The observed price-quantity combinations therefore trace out the time-path of the intersection of the price support level and manufacturing demand only. Thus, the simultaneity of the fluid market and the manufacturing market may be appropriately ignored in estimating the respective demand functions.

The estimated structural equations of the model are listed below. The ratios of the parameter estimates to the standard error (b/SE) are given in parentheses below the coefficients.

TABLE 1: Input Data Utilized for Econometric Estimation

Year	Domestic Milk Production (mil. lbs.)	Adjusted Dairy Cow Numbers	Number of Dairy Cows	Price Support $/cwt.	Slaughter Cow Price $/cwt.	Index of Relative Dairy Price Risk	Fluid Milk Cons. (mil. lbs.)	Mfg. Milk Cons. (mil. lbs.)
1949	116103	35615	23862	$3.14	$18.41	0.8550	53000	55407
1950	116602	35885	23853	3.07	21.48	0.4410	53700	55578
1951	114618	35564	23568	3.60	27.14	0.0820	54800	52723
1952	114617	35070	23060	3.85	21.20	0.1548	55600	50445
1953	120221	36953	23549	3.74	13.60	0.4692	56100	50140
1954	122094	38276	23896	3.15	12.81	0.7272	57200	47916
1955	122945	38809	23462	3.15	12.62	0.1975	58200	52159
1956	124860	40028	23213	3.20	12.25	0.0877	59600	56639
1957	124628	39838	22325	3.25	14.84	0.1710	60400	55596
1958	123220	39649	21265	3.06	19.28	4.7706	60500	44977
1959	121989	38843	20132	3.06	18.80	6.7960	58500	44668
1960	122951	38513	19527	3.23	16.42	10.4223	58500	56208
1961	125442	39410	19271	3.40	16.44	4.5469	57500	59564
1962	126021	39682	18963	3.11	16.35	2.3040	58000	61222
1963	125009	39343	18379	3.14	15.64	1.0155	58800	60645
1964	126967	40465	17647	3.15	13.73	2.8002	58642	62057
1965	124180	39715	16891	3.24	15.07	2.1187	58843	60912
1966	119912	38539	15973	3.75	18.44	2.2472	58531	59404
1967	118732	37911	15129	4.00	17.22	0.3083	56865	57838
1968	117225	37390	14456	4.28	17.65	0.1377	56316	58612
1969	116108	36917	13821	4.28	19.79	0.0797	55197	59221
1970	117007	36725	13303	4.66	20.94	0.2793	54303	59934
1971	118566	37179	13112	4.93	21.21	1.2466	53970	60881
1972	120025	37665	12968	5.11	24.86	1.9340	55151	61300
1973	115491	36753	12828	5.45	32.90	4.3880	54197	61820
1974	115586	36211	12426	6.91	25.45	32.9539	52057	62310
1975	115334	36171	12343	7.48	21.63	1.7843	52628	63435
1976	120269	37600	12207	8.20	26.80	1.1678	52909	64569
1977	122698	38446	12145	9.00	26.11	0.6448	52685	66863
1978	121928	38327	12044	9.87	37.80	0.0548	51286	66528

SOURCE: United States Department of Agriculture, "Agricultural Statistics," Various Years 1950-78.

TABLE 1 continued

Year	Fluid Milk Price $/cwt.	Mfg. Milk Price $/cwt.	Disposable Per Capita Income $	Non-Dairy Bev. Price Index 1967=100	Fats & Oil Price Index 1967=100	Fluid Price Diff $/cwt	All Crop Income Bil. $	Farm Use of Milk Mil. lbs.	Ending Commercial Stocks Mil. lbs.	Production Credit Assoc. Interest Rate %
1949	$4.45	$3.10	$ 483	612	910	$1.45	12396	3163	2990	6.01
1950	4.36	3.16	526	867	885	1.20	12356	3286	3117	6.08
1951	5.02	3.85	533	955	1036	1.17	13239	3449	3566	6.33
1952	5.31	4.06	548	961	878	1.25	14290	3348	4884	6.35
1953	4.82	3.48	577	988	882	1.43	14078	3334	3284	6.36
1954	4.46	3.14	585	1173	929	1.31	13556	3344	3204	5.92
1955	4.50	3.15	628	1051	001	1.35	13523	3266	3601	6.20
1956	4.64	3.25	660	1099	921	1.39	14038	3119	3634	6.66
1957	4.75	3.27	670	1091	962	1.48	12338	2950	3679	6.72
1958	4.66	3.15	674	1014	951	1.51	14229	2767	3783	6.50
1959	4.67	3.17	707	921	907	1.50	14648	2658	3730	7.25
1960	4.69	3.25	723	915	865	1.44	15208	2548	4192	6.61
1961	4.65	3.36	744	915	926	1.29	15660	2432	4992	6.63
1962	4.54	3.20	778	901	925	1.34	16294	2330	4338	6.30
1963	4.53	3.21	808	912	899	1.32	17435	2245	4132	6.47
1964	4.58	3.26	863	1023	896	1.32	17377	2152	4317	6.58
1965	4.63	3.34	916	1015	961	1.29	17392	2061	3918	6.87
1966	5.17	3.97	964	1009	998	1.20	18353	1980	4813	7.29
1967	5.43	4.06	1000	1000	1000	1.37	18434	1981	4358	7.34
1968	5.67	4.22	1038	1019	978	1.45	18620	1821	3983	7.79
1969	5.87	4.45	1057	1046	979	1.42	19541	1745	3798	8.89
1970	6.05	4.70	1089	1174	1053	1.35	20907	1702	3705	7.28
1971	6.19	4.86	1190	1216	1052	1.33	22609	1635	3566	7.02
1972	6.38	5.08	1215	1213	1166	1.30	25520	1624	3493	8.09
1973	7.42	6.20	1140	1302	1290	1.22	41132	1584	4732	9.43
1974	8.66	7.13	1092	1556	1794	1.53	41090	1558	5576	8.91
1975	9.02	7.63	1105	1790	1986	1.39	45150	1567	3719	8.24
1976	9.93	8.56	1210	2140	1737	1.37	58668	1562	5299	7.88
1977	9.96	8.70	1266	3224	1914	1.26	48222	1548	4916	8.83
1978	10.80	9.65	1292	3408	2035	1.15	52051	1499	4475	

Source: United States Department of Agriculture, Agriculture Statistics, Various Years, 1950-1980.

The following equations represent the structural model. The data for estimation were annual observations 1949 - 1978. Values in parentheses are t-values for the respective coefficients. The Durban Watson statistics, DW and DW "h", are also given.

Capital Stock Equation:

$$(24)\quad KC_t = \underset{(4.70)}{18064.87} + \underset{(6.30)}{0.607}\ KC_{t-1} + \underset{(3.94)}{4.182}\ P^s_{gt-1} - \underset{(-3.35)}{1.240}\ CP_{t-1}$$

$$- \underset{(-2.07)}{374.53}\ PCAIR_t + \underset{(2.36)}{27.89}\ RRI_t$$

$R^2 = .88$

DW "h" = 0.68

Domestic Milk Production Equation:

$$(25)\quad Q^{dp}_t = \underset{(9.6)}{2.707} + \underset{(31.8)}{0.853}\ KC_t$$

$R^2 = .94$

Q^{dp}_t and KC were specified in logarithms and the Cochrane-Orcutt procedure was to correct for serial correltaion.

Fluid Milk Demand Equation:

$$(26)\quad FD_t = \underset{(8.57)}{43726.08} - \underset{(-3.88)}{13.86}\ P_{ft} + \underset{(2.66)}{2.29}\ PFS_t + \underset{(3.87)}{43.79}\ RDII_t$$

$$- \underset{(-3.66)}{0.0252}\ RDII^2_t$$

$R^2 = .74$

The Cochrane-Orcutt estimation procedure was used to correct for serial correlation.

Manufacturing Milk Demand Equation:

$$(27)\quad MD_t = \underset{(9.73)}{37696.88} - \underset{(-2.31)}{39.22}\ P_{mt} + \underset{(2.29)}{22.52}\ PFOS_t + \underset{(4.21)}{15.75}\ RDII_t$$

$R^2 = .84$

DW = 1.61

Ending Commercial Stocks Equation:

$$(28)\quad ECSt = \underset{(-1.10)}{-4568.05} + \underset{(2.01)}{.067Q_t^{dp}} + \underset{(4.32)}{10.32\,P_{gt}^{s}} - \underset{(-3.09)}{7.02\,P_{qt-1}^{s}}$$

$$\underset{(-1.61)}{-.4\,PFS_t}$$

$R^2 = .52$
DW = 2.14

The Policy Component of the Model A central theme of this study is that in analyzing the impact of price-supports on prices, production and consumption, the analyst should consider more than a simple one time change in the level of support or simply the current level of price support versus no price support. Price changes are often more gradual, as is evidenced by the magnitude of changes that have occurred since 1980. To analyze this type of policy adjustment, and to be consistent with the rational expectations view, we need to specify a policy rule, i.e., an equation which represents producers aggregate expectations model for dairy price supports. In this way, the level of price support in period t is linked in a logical and explicitly forecastable way to the level in period t-1.

The data for 1949-78 was used to provide three measures of the price-support rule. The first represents the average price support behavior for the entire period, the second, the period from 1949 through 1965 and third, the period from 1966 through 1978. Each of these policy time paths was estimated with a simple one-period autoregressive model, Table 2. Statistically, all three represent reasonable forecasting rules for determining the next periods price support level.[7/] The first indicates that price-supports were increased on the average of 6.7 percent per year for the entire period. The second indicates an esentially fixed price support from 1949-65. The third model indicates an average annual increase in support of 9.5 percent per year from 1966-78.

Table 2: One Period Autoregression Estimates of Alternative Dairy Price Support Equations - Selected Periods, 1949-1978.

Model I: Autoregressive Model 1949-1978

$$P^s_{gt} = \underset{(38.93)}{1.067611} P^s_{gt-1}$$

$$\bar{R}^2 = .98$$

Model II: Autoregressive Model 1949-1965

$$P^s_{gt} = \underset{(15.97)}{0.999236} P^s_{gt-1}$$

$$\bar{R}^2 = .94$$

Model III: Autoregressive Model 1966-1978

$$P^s_{gt} = \underset{(70.19)}{1.09488} P^s_{gt-1}$$

$$\bar{R}^2 = .99$$

The traditional method of policy analysis, that of setting the policy variable to alternative, arbitrary levels from period to period is inconsistent with these models. Such a policy would imply an autoregressive parameter ϕ close to zero with a very large error term. Under such an implied structure, producers would not be able to form any reasonable forecasts of the policy variables, and such a variable would logically not be a determinant in optimal economic decisions. In this model we alter, in a logical way, both the support rule parameters, the the ϕ's, and therfore, the parameters of the reduced form capital stock equation to generate hypothetical behavior for the endogenous variables in the system.

The autoregressions suggest, for model policy evaluation, that we rule out questions such as "what happens if we set the level of price support to zero in 1949 and maintain it there through 1978? Instead, we must pose the more likely question, "What are the implications of a price-support rule which, historically, would have maintained a constant or possibly a more rapidly declining real level of support from 1949 through 1978?

The change in the price support rule is reflected in our econometric model by changing the coefficient on the lagged price-support variable in the capital stock equations. For example, this estimated coefficient on the price-support variable in Equation (24) is 4.182. This coefficient, let's define it as β, is the product of a fixed component, d, which is unchanged with respect to the price-support rule and a variable component ϕ, which varies with the price support rule. Thus $\beta = d\phi$. The value of ϕ was estimated to be 1.0676 for the period 1949-78 with the autoregressive model. Given the estimated value of β and ϕ, $d = \frac{4.182}{1.0676} = 3.917$. If we alter the price-support rule, a new β needs to be calculated. Suppose that a policy of reducing the price support level by 2.5 percent per year. This implies a ϕ of .975. The parameter, β, on the lagged price support variable is now $(.975) \times (3.917) = 3.819$. Each price support policy will define a new β. Each new coefficient generates a different solution to the model.

Model Limitations

Because the focus of this study is on the relative implications of alternative policy specifications under the hypothesis of rationally formulated expectations and risk averse expected utility maximization the model is intentionally kept small. There was no attempt to estimate retail demand and price equations for each of the many dairy products produced. In addition, other limiting assumptions of the model should be made explicit at the outset. First, the model focuses on total domestic production and to lesser extent on the determination of beginning year and ending year commercial stocks, however, farm-use and net imports are taken as exogenous. This is not considered a severe limitation in that these latter variables account for a relatively small percentage of annual domestic milk production and their combined effect is a slight shift in the excess supply curve. Second, government stocks are treated in gross rather than net terms. The federal government will have a demand for dairy products for such programs as nutrition, social welfare, etc. To the extent that these demands are included in the gross quantity of product removed for support purposes, the model will overstate the cost of the price support program.

III. EVALUATION OF ALTERNATIVE DAIRY PRICE SUPPORT POLICIES

At the outset, it should be stated that there is no unique set of alternative policies which could be evaluated. Any number of changes could have occurred in the development and implementation of the price-support program. It seems reasonable, however, that following the turbulent period of the 1940's, the federal dairy price-support policy could have taken one of three reasonable alternative time-paths. The program could have been gradually phased-out; it could have been rapidly eliminated during the 1950's; or it may have been altered at some latter period in response to changing economic conditions. On this basis four reasonable hypothetical policy rules were specified and evaluated as to their economic implications. This was accomplished by first deriving a "model" solution which becomes the basis for comparison. After making the necessary reparameterization called for by the alternative policy rule being evaluated, the model is used to generate estimates of market prices, production levels, fluid and manufacturing demands, and the volume and dollar value of government support purchases for the four alternative policy adjustment paths.

The Base Model Solution 1950-78

To evaluate alternative price-support policies, we need a base solution for comparison. Actual data on the endogenous variables does not provide the appropriate measure for comparison because the model is not an exact replication of the time-paths of the variables.[8/] The base solution is computed by assuming that all exogenous variables in the model follow their historical time path's, 1949-78, and substituting into the model the

Table 3: Base Solution For Econometric Dairy Model 1950-78.

Year	Predicted Standardized Cow #'s	Predicted Milk Production	Predicted Fluid Demand	Predicted Manufacturing Demand	Predicted Ending Commercial Stocks	Forecast Price Support Level
	Thousands	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	$ amount
1950	36497	117374	55979	53881	5502	3.07
1951	36586	117619	55609	55315	5176	3.60
1952	36068	116196	55417	51010	4466	3.85
1953	36597	117647	55963	51989	4161	3.74
1954	37818	120990	57365	55489	3978	3.15
1955	38562	123018	57612	55535	5309	3.15
1956	38929	124017	57970	56294	4716	3.20
1957	39049	124344	57864	57179	4658	3.25
1958	38928	124014	57950	57740	4424	3.06
1959	38362	122475	58058	57268	4757	3.06
1960	37899	121210	58021	55907	4645	3.23
1961	38059	121648	58144	56946	4539	3.40
1962	38155	121910	58641	58597	4191	3.11
1963	38191	122007	58777	58366	4811	3.14
1964	38299	122303	58960	58645	4471	3.15
1965	38546	122976	58979	61036	4681	3.24
1966	38463	122748	58242	60662	5081	3.75
1967	37996	121475	57448	60293	4461	4.00
1968	37944	121335	56719	59298	4580	4.28
1969	37807	120959	56659	59620	4339	4.28
1970	37026	118825	56206	60301	4827	4.66
1971	37223	119364	54620	63064	4401	4.93
1972	37539	120227	53995	63067	4603	5.11
1973	37020	118809	54974	63345	4776	5.45
1974	36145	116408	52059	63632	5528	6.91
1975	36474	117310	51700	65494	3774	7.48
1976	37619	120448	51821	63731	4678	8.20
1977	38185	121991	52329	65463	4189	9.00
1978	38487	122814	51171	65186	4854	9.87

a/ Production + Beginning Stocks + Net Imports = Fluid Use + Manufacturing Use + Ending Commercial Stocks + Government.

Table 3 continued

Year	Predicted Market Clearing Manufacturing Price Short Term Non-support	Predicted Market Clearing Manufacturing Milk Price*	Predicted Fluid Use Price	Predicted All Milk Price	Predicted Government Support Purchases	Predicted Direct Cost of Support Purchases	Support Purchases as Percent of Production
	$/cwt.	$/cwt.	$/cwt.	$/cwt.	Mil. lbs.	$ Mil.	Percent
1950	2.59	3.07	4.27	3.67	2549	78244476	2.1
1951	3.31	3.60	4.77	4.18	1553	55923589	1.3
1952	2.66	3.85	5.10	4.46	6330	243699974	5.4
1953	2.54	3.74	5.08	4.40	6372	238303035	5.4
1954	2.23	3.15	4.46	3.79	4880	153728115	4.0
1955	2.18	3.15	4.50	3.81	5154	162354221	4.1
1956	2.14	3.20	4.59	3.87	5623	179934107	4.5
1957	2.13	3.25	4.73	3.96	5945	193212771	4.7
1958	2.05	3.06	4.57	3.78	5357	163935915	4.3
1959	2.31	3.06	4.56	3.79	4005	122544256	3.2
1960	2.41	3.23	4.67	3.94	4373	141252861	3.6
1961	2.62	3.40	4.69	4.03	4131	140449192	3.3
1962	2.60	3.11	4.45	3.77	2718	84541603	2.2
1963	2.92	3.14	4.46	3.80	1169	36718274	0.9
1964	3.27	3.27	4.59	3.93	0	0	0.0
1965	3.25	3.25	4.54	3.88	0	0	0.0
1966	3.14	3.75	4.95	4.32	3235	121326281	2.6
1967	3.20	4.00	5.37	4.65	4266	170632500	3.5
1968	3.44	4.28	5.73	4.96	4451	190489684	3.6
1969	3.56	4.28	5.70	4.95	3834	164086740	3.1
1970	4.42	4.66	6.01	5.30	1282	59742304	1.0
1971	4.84	4.93	6.26	5.54	495	24415220	0.4
1972	4.74	5.11	6.41	5.70	1937	98976833	1.6
1973	5.10	5.45	6.67	6.01	1346	73354361	1.1
1974	8.08	8.08	9.61	8.77	0	0	0.0
1975	8.76	8.76	10.15	9.37	0	0	0.0
1976	7.41	8.20	9.57	8.79	4163	341362247	3.4
1977	8.24	9.00	10.26	9.54	4036	363262421	3.3
1978	8.73	9.87	11.02	10.35	6056	597728562	4.9

* either the short-term non-support price or the established support price, whichever is greater.

values of any lagged endogenous variables predicted by the model from the previous period(s). The predicted annual levels, 1950 to 1978, for the endogeneous variables in the base solution are given in table 3.

The comparison of the time-series for predicted with actual endogeneous variables indicates that there is generally good agreement. The Theil Inequality Coefficient U and its mean variance and covariance components were calculated for each of the endogeneous variables in the system.[9/] The U coefficients were all within the critical range of (0,1), indicating that the model forecasts reasonably well. The decomposition of the mean square forecast error indicates that for the variables taken together, the largest proportion of forecast error lies with the random component. There is no evidence of systematic bias in either the means or variances of the endogeneous variables.

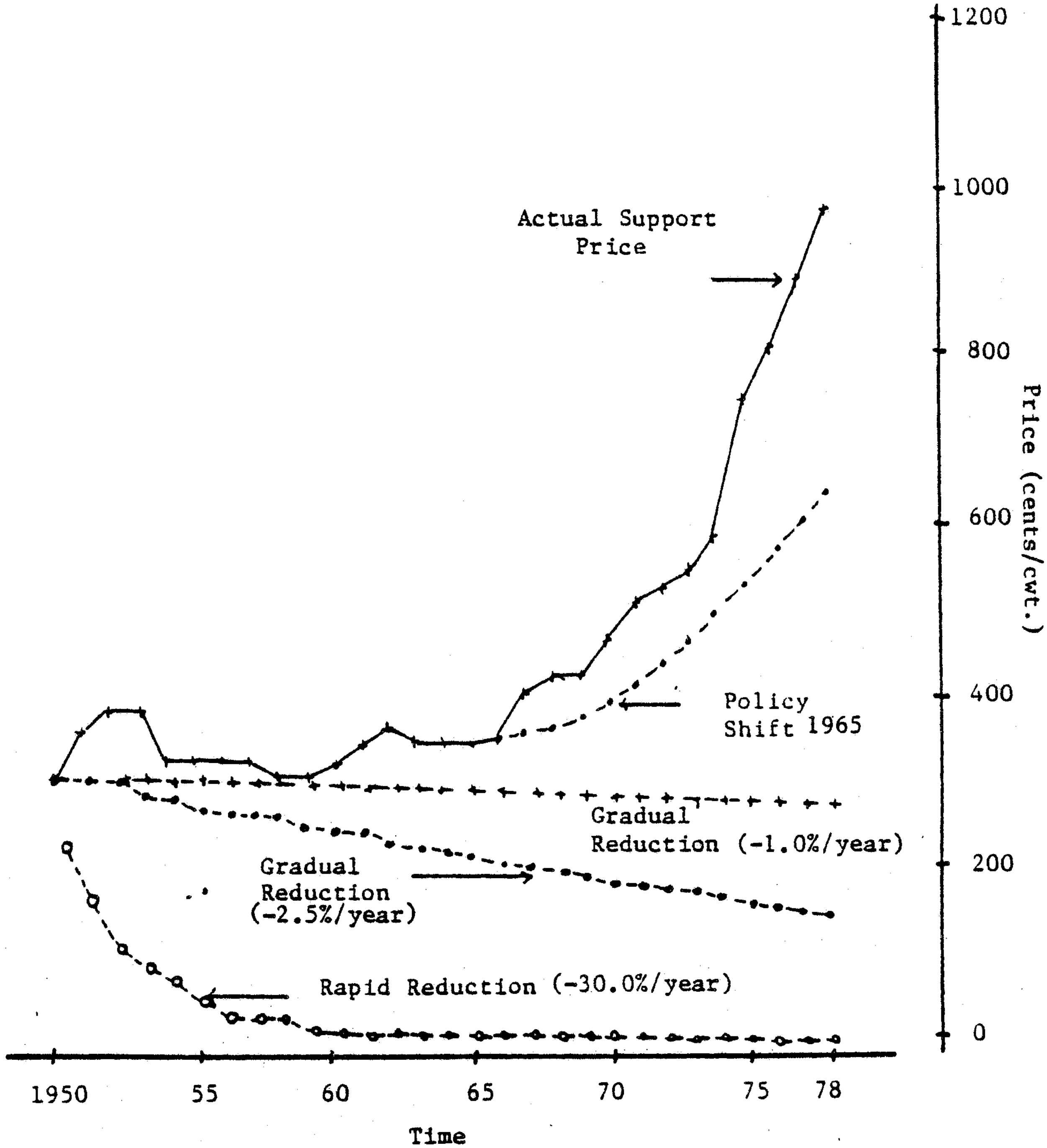
The time-path for the predicted equilibrium market price for manufacturing use milk is that price at which manufacturing milk demand is equal to the total available manufacturing supply of milk. The variable is an unobservable quantity in the market as long as supply and demand conditions are such that the equilibrium price is strictly less that the established federal dairy price support level. It should be clear that this equilibrium price is no the "free-market" price which would have been obtained in the absence of a price-support program, unless the market naturally clears at a price in excess of the support-price. As long as the equilibrium price is below the support-price, it is the short-term market price necessary to clear the current period supply should the price-support level be announced but not maintained by the support authorities. Note that the equilibrium price exceeded the price support level in only 4 years during the 29 year period. The time-path of the equilibrium price illustrated here, does not take into account dynamic supply adjustments via capital capacity (KC) which would occur with alternative price-support policies.

As noted above, the model generated time-paths of the endogenous variables are used as the base against which to evaluate alternative price-support policies. In the remainder of this section, we will examine the implications for price levels and market quantities of four alternative hypothetical support policies over the period 1950-1978. These alternative policies are: (i) gradually declining level of nominal price-support, with the reduction equal to -1% per year and -2.5% per year respectively; (ii) a rapidly declining level of price-support(-3% per year); and (iii) a price-support policy that follows the actual historical time-path through 1965 and then increases at fifty percent of the actual annual rate, i.e., 4.7% as compared to 9.5% from 1966 to 1978.

Impacts of Four Alternative Price Support Adjustment Paths

Parity percentages for Milk Prices The time-paths of the price-support levels under each policy parameter are graphed in Figure 3. A policy is defined as a rule or law of motion which guides the setting of the level of price-support from one production period to the next. From the producers point of view this rule is approximated as $P^s_{gt} = \phi P^s_{gt-1}$. The level of ϕ serves to identify each policy: in the base solution where $\phi = 1.0676$; the gradual declines in the support price where $\phi = 0.99$ and $\phi = 0.975$; the rapid decline in the support price where $\phi = 0.70$; and the last case, when

Figure 3: U.S. Federal Dairy Price-Support: Actual and Alternative Policies: 1950-78.



the support price rule changes to a slower rate of increase represented by $\phi = 1.047$.

The price-support level actually experienced was established each year as a specified percent of the milk parity price.[10/] Each of the new policy parameters ϕ translates into a parity equivalent prices for the period 1950-78. The parity price and parity percentages for the alternatives are listed in Table 4. Under the gradually declining policies $\phi = 0.99$ and $\phi = 0.975$, the price-support level would have declined from 75 (56) percent of the parity milk price in 1950 to 21 (13) percent respectively by 1978. The rapidly declining policy, $\phi = 0.70$, has the effective support level virtually eliminated by the late 1950's. The policy = 1.047 implies a parity percentage equivalent to that actually established up through 1965, but allows this level to decline to 53 percent by 1978. Note that in both the case for the gradual reduction an the rapid decline, the actual level of the price-support is declining over time. For the last case, however, the level is increasing but at a slower annual rate than for the actual support price.

Manufacturing Use Milk Prices The first question to be addressed with respect to the alternative policies concerns the relative levels of support and market prices for manufacturing milk over the period 1950-78. If the price support authority had followed an alternative price support rule for supporting price, how would the manufacturing milk prices have compared to those which were actually realized? The model generated the manufacturing milk prices that would have prevailed under each of the policies alternatives. As described above the price support level is the

Table 4: Parity Percentages for Hypothetical Support Policies: Selected Years 1950-1978.

Year	Parity Milk Price $/cwt.	Selected Price Support Policies: Gradually Declining Support -1%/year %	Gradually Declining Support -2.5%/year %	Rapidly Declining Support -30%/year %	Reduced Rate of Support Increase After 1965 (+4.7%/year) %
1950	$4.13	75.0	56.0	53.0	74.0
1955	4.20	70.0	64.0	9.0	75.0
1960	4.02	70.0	59.0	1.5	80.0
1965	4.29	62.0	49.0	-	75.0
1978	11.12	21.0	13.0	-	53.0

equilibrating price in the manufacturing market whenever commercial supply and demand produce an equilibrium price that is lower than the price support price. In reality the support price has set the manufacturing milk price in all but three years over the entire period 1950-78.

The four alternative price support rules generate considerably different manufacturing milk prices, Table 5. With the most gradual reduction in support price level, i.e., -1% per year beginning in 1950, the manufacturing milk price is effectively established by the alternative support price through 1963, with the exception of 1951. After 1963, the alternative support price no longer establishes the market price for manufacturing use milk. The interesting thing about these results is that after 1968, 18 years after the initiation of reduced support levels, the market price for manufacturing milk rises above the support prices that actually prevailed in 1969. The 1969 market price would have been $4.34/hundredweight. The actual support price was $4.28/hundredweight. The predicted market prices then remain consistently above the actual support prices or market prices that prevailed after that period of time. This analysis shows that by 1978 market price for manufacturing use milk would have risen to $11.80 per hundredweight in comparison with the actual support price which was effective in that year of $9.87/hundredweight.

These results support the hypothesis that the supply enhancing impact of price stability that is generated by the price support program shifts the supply to the right by an amount sufficient to eventually bring about milk prices lower than those that would prevail in the absence of a price support program. Note, however, that this takes a considerable amount of time, in this case, eighteen years. Similar results obtain for the

Table 5: U.S. Manufacturing Use Milk Prices for Four Price Support Adjustment Policies, 1950-1978.

Manufacturing Milk Price With:

Year	Actual Support Price	Base Model Support Price	Gradually Declining Support (-1%/yr)	Gradually Declining Support (-2.5%/yr)	Rapidly Declining Support (-30.0%/yr)	Reduced Rate of Support Increase After 1965 (+4.7%/yr)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
			$/cwt.			
1950	3.07	3.35*	3.11*	3.06*	2.60	3.35*
1951	3.60	3.28	3.26	3.28	3.67	3.28
1952	3.85	3.84*	3.05*	2.92*	3.52	3.84*
1953	3.74	4.11*	3.01*	2.98	3.78	4.11*
1954	3.15	3.99*	2.99*	2.77*	3.74	3.99*
1955	3.15	3.36*	2.96*	2.70*	3.55	3.36*
1956	3.20	3.36*	2.93*	2.63*	3.63	3.36*
1957	3.25	3.42*	2.90*	2.56*	3.67	3.42*
1958	3.06	3.47*	2.87*	2.50*	3.65	3.47*
1959	3.05	3.27*	2.84*	2.50	3.67	3.27*
1960	3.23	3.27*	2.81*	2.38*	3.33	3.27*
1961	3.40	3.45*	2.78*	2.78	3.95	3.45*
1962	3.11	3.63*	2.76*	3.04	4.20	3.63*
1963	3.14	3.32*	2.73*	3.33	4.48	3.32*
1964	3.15	3.35*	3.01	3.83	4.96	3.35*
1965	3.24	3.36*	3.24	3.85	4.96	3.36*
1966	3.75	3.46*	3.23	3.74	4.83	3.39*
1967	4.00	4.00*	3.60	4.04	5.10	3.55*
1968	4.28	4.27*	3.98	4.38	5.41	3.71*
1969	4.28	4.57*	4.34	4.72	5.73	3.89*
1970	4.66	4.57*	5.20	5.58	6.57	4.57
1971	4.93	4.97*	5.87	6.24	7.21	5.13
1972	5.11	5.26*	5.96	6.33	7.27	5.11
1973	5.45	5.45*	6.54	6.92	7.84	5.58
1974	6.91	5.82	9.64	10.00	10.82	8.48
1975	7.48	7.38	10.93	11.31	12.14	9.68
1976	8.20	7.98*	9.75	10.14	10.97	8.39
1977	9.00	8.75*	10.92	11.33	12.16	9.45
1978	9.87	9.61*	11.80	12.22	13.04	10.19

* Indicates that the support price is the effective manufacturing use milk price.

slightly more rapid price-support reduction of 2.5 percent per year, Table 5, Column 5.

The impact of a rapidly declining support price on manufacturing milk prices is shown in Table 5, Column 6. The government would have been immediately removed from establishing market prices. At no time during the twenty-nine year period did the government set the market price for milk. For some period of time there was an effective floor below which prices could not fall. One may argue that once the price support level falls below 40 or 50% of the actual average market price it is no longer a meaningful floor price. The uncertainty generated in this kind of a situation leads to even larger impacts on the supply of milk. In fact, supply changes so rapidly in response to this elimination of government intervention that the actual market prices very quickly rise above the price that were achieved either through price support or in the market place. Our analysis shows that by 1953 market price is above the support price that would have prevailed. One of the reasons for this very rapid adjustment is probably that in 1951 there was no effective government price support activity. The certainty that there would be a price support program at that specified minimum level subsequently generated a large enough supply of milk so that the prices were forced down to the support level. However, with the declining level of support induced investment and less certainty about future prices in dairying, herd expansion would not have been sufficient to maintain total milk supply at the level that actually prevailed. By 1978, milk prices would have been an estimated 32% higher than the actual support price at that time.

A third price support adjustment scenario was one where the support price followed the same time path that actually observed from 1950-1965, then increased but at a slower rate than what actually ocurred through 1978. The manufacturing milk prices in this case is illustrated in the last column of Table 5. Examination of the time path of the actual support price reveals that it was increased very little over the period 1949-1965. After 1965 the rate of increase accelerated because of the rapidly increasing parity index. The estimated annual rate of increase over the period 1966-1978 is 9.5%. Policy making authorities who recognized the changing economic environment in 1966 and the potential for a rapidly increasing support costs could have opted to begin a reduction in the support as a percentage of parity. By setting $\phi = 1.047$ the rate of increase would have been one half the annual rate actually observed over the 1966-78 period. It would have changed the price support target level from 81% percent of parity in 1950 to approximately 53% in 1978, (Table 4).

The alternative policy would have reduced capital from 38.7 to 35.5 million animal units and domestic production from 120.4 to 114.7 billion pounds over the period 1966-78. These changes are accompanied by a slight increase in the market clearing price but not to level substantially greater than the actual price support level over the same period. The market equilibrium price in 1978 is $10.19/hundredweight compared to $9.87/hundredweight established by the actual price support program. With this policy alternative the role of the federal government as a purchaser of surplus dairy products for price supports would have been eliminated by 1971-72.

Fluid Milk Prices Because of the administratively determined relationship between fluid milk use prices and manufacturing milk prices, the fluid milk price behaves very much as the manufacturing milk price under the alternative price support rules that were evaluated. Fluid milk prices under both gradual reduction alternatives would not have risen permanently above the base model fluid price until 1969 for the 1% per year decline and until 1963 for the 2.5% per year decline. By 1978, the fluid milk price under these options is from 1.93 to 2.35 per hundredweight above predicted base land fluid milk price, Table 6, Columns 2 and 3. With the rapidly declining level of support the fluid milk price rises permanently above that which was generated in the base model after 1952, Table 6, Column 4. And, in this case, by 1978 the actual market generated fluid milk price was $3.17/hundredweight in excess of that which was generated in the base model. The option of the reduced level of support price increase after 1965 reduced the fluid milk prices for the period 1966 through 1970, Table 6, Column 5. Thereafter, the market price again rose above those which were generated in the base model and were $.32/hundredweight above those which actually prevailed by 1978.

The U.S. All Milk Price This is an average of the prices for milk in manufacturing and fluid uses weighted by the proportions of milk used in each of these markets. For the gradually declining level of support options, the all U.S. milk price is below that which was generated by the base model for a considerable time. For the gradual 1% reduction this was the situation for the period 1950 to 1968 and for the 2.5% reduction this

Table 6: Average U.S. Fluid Milk Prices for Four Price Support Adjustment Policies, 1950-1978.

		Fluid Milk Price With			
Year	Base Model Support Price	Gradually Declining Support (#1) -1%/year	Gradually Declining Support (#2) -2.5%/year	Rapidly Declining Support -30%/year	Reduced Rate of Support Increase After 1965 +9.7%/year
	(1)	(2)	(3) $/cwt.	(4)	(5)
1950	4.27	4.31	4.26	3.86	4.55
1951	4.77	4.42	4.45	4.84	4.44
1952	5.10	4.29	4.17	4.77	5.09
1953	5.08	4.35	4.32	5.12	5.45
1954	4.46	4.29	4.07	5.05	5.30
1955	4.50	4.30	4.05	4.90	4.71
1956	4.59	4.32	4.02	5.03	4.75
1957	4.73	4.37	4.04	5.15	4.89
1958	4.57	4.38	4.01	5.16	4.97
1959	4.56	4.34	4.00	5.17	4.76
1960	4.67	4.25	3.81	4.78	4.70
1961	4.69	4.07	4.07	5.25	4.73
1962	4.45	4.09	4.38	5.55	4.96
1963	4.46	4.05	4.64	5.80	4.64
1964	4.59	4.33	5.15	6.28	4.67
1965	4.54	4.53	5.14	6.25	4.65
1966	4.95	4.43	4.94	6.03	4.59
1967	5.37	4.96	5.41	6.47	4.92
1968	5.73	5.43	5.83	6.87	5.17
1969	5.70	5.75	6.13	7.15	5.31
1970	6.01	6.55	6.92	7.93	5.93
1971	6.26	7.19	7.57	8.54	6.47
1972	6.41	7.25	7.62	8.57	6.41
1973	6.67	7.76	8.14	9.06	6.80
1974	9.60	11.17	11.54	12.35	10.01
1975	10.14	12.32	12.70	13.53	11.07
1976	9.57	11.12	11.52	12.34	9.77
1977	10.26	12.18	12.60	13.42	10.71
1978	11.02	12.95	13.37	14.19	11.34

Table 7: Average All U.S. Milk Prices for Four Price Support Adjustment Policies, 1950-1978.

	Average All U.S. Milk Price with				
Year	Base Model Support Price	Gradually Declining Support (-1%/year)	Gradually Declining Support (2.5%/year)	Rapidly Declining Support (-30.0%/year)	Reduced Rate of Support Increase After 1965 (+4.7%/yr)
	(1)	(2)	(3)	(4)	(5)
			$/cwt.		
1950	3.66	3.70	3.65	3.24	3.94
1951	4.18	3.84	3.86	4.26	3.86
1952	4.46	3.68	3.56	4.17	4.46
1953	4.40	3.70	3.66	4.47	4.76
1954	3.79	3.64	3.43	4.42	4.62
1955	3.81	3.62	3.37	4.25	4.01
1956	3.87	3.61	3.32	4.35	4.03
1957	3.96	3.61	3.30	4.43	4.12
1958	3.78	3.53	3.25	4.42	4.19
1959	3.79	3.53	3.25	4.44	3.99
1960	3.94	3.49	3.09	4.07	3.97
1961	4.03	3.40	3.42	4.61	4.08
1962	3.77	3.41	3.71	4.89	4.28
1963	3.80	3.38	3.99	5.16	3.97
1964	3.93	3.67	4.50	5.65	4.01
1965	3.88	3.87	4.49	5.62	4.00
1966	4.32	3.81	4.33	5.44	3.98
1967	4.65	4.26	4.71	5.78	4.21
1968	4.96	4.69	5.09	6.14	4.41
1969	4.95	5.03	5.41	6.45	4.58
1970	5.30	5.86	6.24	7.25	5.23
1971	5.54	6.50	6.87	7.86	5.76
1972	5.70	6.56	6.94	7.90	5.72
1973	6.01	7.12	7.50	8.44	6.15
1974	8.77	10.35	10.72	11.55	9.18
1975	9.37	11.57	11.95	12.80	10.31
1976	8.79	10.38	10.78	11.62	9.01
1977	9.54	11.51	11.92	12.75	10.01
1978	10.35	12.33	12.75	13.58	10.69

is true through 1962, Table 7, Columns 2 and 3. Thereafter, the average price rose above that which was generated by the base solution model. For the rapidly declining support rule the all U.S. milk price permanently rose above the base solution model after 1952. By 1978 the all U.S. milk price was approximately $3.23 above the price generated in the base model. The policy change where the rate of support price increase was reduced after 1965 resulted in all U.S. milk prices that were not substantially different after 1966 than those that actually prevailed, Table 7, Column 5.

Milk Production Alternative price-support policies would generate milk production adjustments because of impacts on the level of risk and uncertainty as well as the charge in prices generated within the sector as well as changes in risk and uncertainty. These impacts for the policy changes are illustrated in Table 8. All of the policy changes bring about reduced levels of milk production relative to those that either actually occurred or were generated in the base model solution. The rapidly declining price support caused the greatest decline in total milk production. The total U.S. milk production was 23.3 billion pounds or 19% less than generated in the base solution by 1978, Table 8, Column 3. The gradually declining levels of support lead to the reduction of milk supply of 13.6% and 15.5% respectively in 1978. The policy option that reduced the rate of increase in price support after 1965 resulted in the smallest reductions in milk supplies. However, total U.S. production would have been lower in each of the years following this policy shift. By 1978 the production was approximately 6.5% lower than the base model.

Table 8: Total U.S. Milk Production for Four Price Support Adjustment Policies, 1950-1978.

Total Milk Production with:

Year	Base Model Price Support	Gradually Declining Support (-1%/yr)	Gradually Declining Support (-2.5%/yr)	Rapid Declining Support (-30%/yr)	Reduced Rate of Support Increase After 1965 (+4.7%/yr)
	(1)	(2)	(3)	(4)	(5)
			Million lbs#		
1950	117374	117112	117061	116131	117374
1951	117619	117245	117114	114987	117619
1952	116196	115112	114884	111594	116196
1963	117647	115862	115506	111210	117647
1954	120990	119798	118643	113351	120990
1955	123018	122633	120991	115242	123018
1956	124017	123679	122033	116007	124017
1957	124344	124330	122269	116105	124344
1958	124014	135226	122052	115711	124014
1959	122475	130616	121286	115064	122475
1960	121210	127731	121972	116135	121210
1961	121648	126305	120843	114660	121648
1962	121910	124043	119846	113664	121910
1963	122007	123037	119499	113393	122007
1964	122303	123629	119310	113315	122303
1965	122976	122969	119655	113781	122976
1966	122748	121724	119053	113297	122677
1967	121475	119380	117064	111426	121248
1968	121335	118271	116179	110679	120641
1969	120959	116947	114948	109558	119822
1970	118825	114183	112213	106927	117610
1971	119364	113819	111848	106687	117802
1972	120227	113756	111763	106732	118314
1973	118809	111389	109363	104467	116584
1974	116408	106795	104824	100539	113058
1975	117310	106083	104028	99671	112831
1976	120448	107595	105470	101106	114907
1977	121991	107284	105094	100750	115251
1978	122814	106029	103775	99469	114724

Reduced total milk production with lower levels of price support or with no price support is consistent with most other studies of impacts of price support programs. However, one should keep in mind that these lower levels of production occur, in some years, with higher prices than prevailed without the actual price support program. This occurs because of the leftward shift in the aggregate supply function brought about by increased levels of relative risk.

Milk Product Consumption The impacts of the price support changes on dairy products consumption are inversely related to their impacts on fluid and manufactured dairy product prices. In those years when prices are increased production consumption declines. In those years when the price support program reduces product prices consumption for the individual products are increased, Tables 9 and 10. With gradually declining levels of support both total fluid milk consumption and manufactured production consumption would not have been greatly different than those realized until about 1970. Thereafter, increasing prices for both fluid use and manufacturing use milk lead to declines in consumption. By 1978, fluid milk consumption has declined by 5% to 6% from the base model level and manufactured dairy products consumption has been reduced by 11.6 to 14.1 percent.

With rapidly declining levels of support price the demand for milk used in these products leads to even greater declines in consumption. By 1978, fluid milk consumption is 4.3 billion pounds less and manufactured dairy production consumption is 12.4 billion pounds less than generated by the base solution model or 8.5% and 19% less respectively for fluid and manufactured dairy products.

For the reduced rate of price support increase after 1965 fluid and manufactured dairy product consumption is increased over what it was with the base model solution through 1970 (Tables 9 and 10, Column 5. Thereafter, fluid and manufactured dairy product consumption falls below the base solution consumption. By 1978, fluid milk consumption is 1% less than the base model solution and manufactured dairy product consumption is down about 9% from the base model level.

Price Support Purchases As would be expected any policy changes that leads to a lower level of price support also leads to fewer government price support purchases to maintain milk prices (Table 11). With the most gradual reduction of support there are thirteen years in which the commodity credit corporation would have made purchases in order to maintain the new level of price support. This is reduced to 7 years with the 2.5 % per year reduction policy. With the rapidly declining level of support, no purchases were needed since market prices exceeded the new support price in every year. With the reduced rate of support price increase after 1965, support purchases continued for four years but at a substantially reduced level than were maintained prior to the policy shift.

Table 9: U.S. Fluid Milk Consumption for Four Price Support Adjustment Policies, 1950-1978.

	Total Fluid Milk Consumption with:				
Year	Base Model Support	Gradually Declining Support (-1.%/yr)	Gradually Declining Support (-2.5%/yr)	Rapidly Declining Support (-30%/yr)	Reduced Rate of Support After 1965 (+4.7%/yr)
	(1)	(2)	(3)	(4)	(5)
			Million Pounds		
1950	55979	55925	55990	56630	55979
1951	55609	56081	56051	55511	55609
1952	55417	56531	56708	55868	55417
1953	55963	56967	57014	55909	55963
1954	57365	57592	57897	56541	57365
1955	57612	57881	58240	57059	57612
1956	57970	58349	58760	57365	57970
1957	57864	58352	58814	57275	57864
1958	57950	58216	58726	57126	57950
1959	58058	58364	58833	57206	58058
1960	58021	58602	59204	57870	58021
1961	58144	58999	58999	57373	58144
1962	58641	59133	58736	57121	58641
1963	58777	59349	58517	56918	58777
1964	58960	59325	58188	56617	58960
1965	58979	58997	58148	56608	58979
1966	58242	58967	58254	56745	58738
1967	57448	58010	57396	55918	58069
1968	56719	57133	56583	55141	57498
1969	56659	56582	56058	54644	57115
1970	56206	55452	54937	53551	56318
1971	54620	53319	52806	51453	54329
1972	53995	52830	52312	50992	53989
1973	54974	53467	52939	51655	54791
1974	52059	49899	49387	48262	51500
1975	51701	48696	48160	47008	50415
1976	51821	49675	49123	47982	51551
1977	52329	49661	49091	47954	51705
1978	51171	48495	47909	46782	50727

Table 10. U.S. Manufactured Dairy Product Consumption for Four Price Support Adjustment Policies, 1950-1978.

	Total Manufactured Milk Products Consumption on Whole Milk Equivalent with:				
Year	Base Model Price Support	Gradually Declining Support (-1%/yr)	Gradually Declining Support (-2.5%/yr)	Rapidly Declining Support (-30.0%/yr)	Reduced Rate of Support Increase After 1965 (+4.7%/yr)
	(1)	(2)	(3)	(4)	(5)
			Million Pounds		
1950	53881	53730	53915	55724	53881
1951	55315	56650	56567	55038	55315
1952	51010	54162	54663	52285	51010
1953	51989	54828	54962	51836	51989
1954	55489	56131	56992	53157	55489
1955	55535	56295	57311	53970	55535
1956	56294	57366	58530	54181	56294
1957	57179	58562	59869	55513	57179
1958	57740	58491	59936	55409	57740
1959	57268	58132	59459	54858	57268
1960	55907	57550	59255	55478	55907
1961	56946	59365	59364	54765	56946
1962	58597	59988	58865	54303	58597
1963	58366	59983	57629	53105	58366
1964	58645	59678	56461	52016	58645
1965	61036	61086	58682	54326	61036
1966	60662	62713	60695	56426	62065
1967	60293	61883	60147	55964	62052
1968	59298	60470	58112	54832	61500
1969	59620	59401	57919	53919	61136
1970	60301	58166	56711	52790	60617
1971	63064	59384	57931	54103	62242
1972	63067	59771	58303	54570	63050
1973	63345	59081	57589	53957	62828
1974	63632	57521	56071	52888	62051
1975	65494	56993	55476	52217	61858
1976	63731	57659	56098	52868	62966
1977	65463	57912	56301	53084	63696
1978	65186	57616	55958	52767	63930

Table 11: U.S. Government Price Support Purchases for Four Price Support Adjustment Policies, 1950-1978.

Total Product Removals in Whole Milk Equivalent with:

Year	Base Model Support	Percent of Domestic Production	Gradually Declining Support (-1%/yr)	Percent of Domestic Production	Gradually Declining Support (-2.5%/yr)
	Mil. lbs.	%	Mil. lbs.	%	Mil. lbs.
1950	2549	2.2	4197	3.5	3869
1951	1553	1.3			0
1952	6330	5.4	884	0.7	0
1953	6372	5.4	512	0.4	0
1954	4880	4.0	2343	1.9	44
1955	5154	4.2	4125	3.3	1174
1956	5623	4.5	3841	3.1	664
1957	5945	4.8	4081	3.2	264
1958	5357	4.3	15309	11.2	219
1959	4005	3.3	10365	7.9	0
1960	4373	3.6	9063	7.0	747
1961	4131	3.4	5688	4.5	0
1962	2718	2.2	2685	2.1	0
1963	1169	1.0	424	0.3	0
1964	0	0	0	0.0	0
1965	0	0	0	0.0	0
1966	3235	2.6	0	0.0	0
1967	4266	3.5	0	0.0	0
1968	4451	3.7	0	0.0	0
1969	3834	3.2	0	0.0	0
1970	1282	1.1	0	0.0	0
1971	495	.4	0	0.0	0
1972	1937	1.6	0	0.0	0
1973	1346	1.1	0	0.0	0
1974	0	0	0	0.0	0
1975	0	0	0	0.0	0
1976	4163	3.5	0	0.0	0
1977	4036	3.3	0	0.0	0
1978	6056	4.9	0	0.0	0

Table 11 Continued: U.S. Government Price Support Purchases for Four Price Support Adjustment Policies, 1950-1978.

	Total Product Removals in Whole Milk Equivalent with:				
Year	Percent of Domestic Production	Rapidly Declining Support (-30%/yr)	Percent of Domestic Production	Reduced Rate of Support Price Increase After 1965	Percent of Domestic Production
	%	Mil. lbs.	%	Mil. lbs.	%
1950	3.3	0	0	2549	2.1
1951	0.0	0	0	1553	1.3
1952	0.0	0	0	6330	5.4
1953	0.0	0	0	6372	5.4
1954	0.0	0	0	4880	4.0
1955	0.0	0	0	5154	4.1
1956	.9	0	0	5623	4.5
1957	.5	0	0	5945	4.7
1958	.2	0	0	5357	4.3
1959	.1	0	0	4005	3.2
1960	.6	0	0	4373	3.6
1961	0.0	0	0	4131	3.3
1962	0.0	0	0	2718	2.2
1963	0.0	0	0	1169	0.9
1964	0.0	0	0	0	0.0
1965	0.0	0	0	0	0.0
1966	0.0	0	0	1634	1.3
1967	0.0	0	0	1506	1.2
1968	0.0	0	0	840	0.6
1969	0.0	0	0	416	0.3
1970	0.0	0	0	0	0.0
1971	0.0	0	0	0	0.0
1972	0.0	0	0	0	0.0
1973	0.0	0	0	0	0.0
1974	0.0	0	0	0	0.0
1975	0.0	0	0	0	0.0
1976	0.0	0	0	0	0.0
1977	0.0	0	0	0	0.0
1978	0.0	0	0	0	0.0

Sensitivity of Adjustments to Alternative Parameter Values

It is important to consider whether the same general results for price, production and consumption behavior would obtain with different supply and demand parameters. In a preceding section, it was shown that the rate at which this equilibrium milk price would approach and finally exceed the price-support level depended in large part on the slope of the manufacturing demand function. With less slope and, therefore, a higher elasticity of demand, reductions in support prices will have less impact on the equilibrium market prices. To determine how sensitive policy evaluations are to alternative manufacturing demand price slopes, model solutions were derived using the lower bound of the 90 percent statistical confidence interval for the price coefficient in the manufacturing demand function.

In addition to determining the sensitivity of the model to changes in the manufacturing price parameter, we also examined the sensitivity of the model to changes in the coefficient on fluid milk price in the fluid demand equation and the lagged support price coefficient in the capital stock equation. Again, the lower value of the 90 percent statistical confidence was computed for the estimated coefficients. The values for the lower bounds were used to simulate the alternative price-support policies. The lower bound values translate into more elastic demands for dairy products and more inelastic milk supply.

The sensitivity of the model solutions to four alternative elasticity specifications were estimated. These four alternatives are (i) a more elastic manufacturing demand function; (ii) a more elastic fluid demand function; (iii) a less price-support responsive capital stock equation, and (iv) both a more elastic manufacturing demand function and a less price responsive capital stock function. The sensitivity of the model solution is illustrated in Table 12. The average annual values of domestic milk production, the market clearing price and the producers weighted all milk price can be compared to their respective base solutions for each of the demand and supply elasticity changes.

More Elastic Manufacturing Demand With the manufacturing price parameter set equal to -78.28, the price elasticity of demand at average values of price and quantity increases from a -0.30 to -0.61. Predicted domestic milk production responds to the alternative support-price policies in much the same manner as under the original model, declining in all cases (compare row 1 and 2, Table 12). However, the more elastic manufacturing milk demand function causes the market clearing prices to decline for the two gradual support-price policies. With a less price-responsive manufacturing demand, the gradually declining support price is the market clearing price for a much longer period of time and results in an annual average price which actually declines 10.7 or 8.2 percent for the period. (row 7, Table 12). The use weighted all milk price exhibits the same pattern as the market clearing price. The largest declines occurs for the gradual policy changes by 9.0 and 6.4 percent (row 12, Table 12).

More Elastic Fluid Milk Demand With this alternative parameter specification the elasticity of fluid demand with respect to the fluid milk price increases from a -0.13 in to a -0.22. The impact of this change on predicted domestic production is similar, over all alternative policies, to the initial policy analyses (compare rows 1 and 3, Table 12). The impact on market clearing price is also the same, however, the magnitude is not as pronounced. Manufacturing milk prices increase but by not as for the less elastic demand, much as measured by the compare the annual average values in rows 6 and 8, Table 12. This also holds for the use weighted all milk price (compare rows 11 and 13, Table 12).

Less Elastic Milk Supply In the model developed in this study, milk production responds to changes in support price through the capital stock equation. In this alternative, this responsiveness is lowered by decreasing the coefficient value on dairy support price in the capital stock equation. The impact on domestic milk production is as expected. Under all of the alternative support policies domestic production declines but not as much as for the initial policy analyses (compare rows 1 and 4, Table 12). The impact on prices is similar to those impacts but of a lower magnitude. Prices, both market clearing and all milk increase over time, but the average annual percentage increase is much less, (compare rows 11 and 14, Table 12).

More Elastic Manufacturing Milk Demand and Less Elastic Milk Supply The last alternative specifies both a more elastic manufacturing demand function and a less responsive capital stock function. This combination of coefficients generates the largest difference from the initial policy change solutions. As expected, milk production does not decline as much as with initial parameter velues. Furthermore, average manufacturing prices and all milk prices fall rather than increase (compare rows 1 and

5, 6 and 20, 11 and 15, Table 12). The largest price decline occurs for the most gradually declining price support level and the least fall for the rapid support price decline.

The sensitivity analysis indicates important impacts which would be derived under alternative parameter specifications. With more elastic manufacturing demand and/or the less price responsive capital stock, the less likely it is that prices under the alternative price-support policies would have exceeded prices which actually prevailed. Nevertheless, it still supports the argument that models which neglect both the affects of risk and rationally formed producer expectations result in biased supply adjustment parameters which understate the reduced supply affect on market prices.

Table 12: Comparison of Predicted Annual Average U.S. Milk Production and Price with Alternative Parameter Values and Alternative Price- Support Policies 1950-1978.

Variable	Row	Parameter Change:	Base Model Simulation With Actual Price-Support Levels (%Δ)		Gradual Reduction (-1%/yr) In Support Price (%Δ)		Gradual Reduction In Support-Price (-2.5%/yr) (%Δ)		Rapid Reduction In Support-Price (-30%/yr) (%Δ)		Reduced Rate of Increase in Support Price After 1965 (+4.7%/yr) (%Δ)	
			(1) Bil. lbs.	(2) %Δ	(3) Bil. lbs.	(4) %Δ	(5) Bil. lbs.	(6) %Δ	(7) Bil. lbs.	(8) %Δ	(9) Bil. lbs.	(10) %Δ
Total	(1)	None	120.774	-	118.364	-2.0	115.468	-4.4	110.402	-8.6	119.490	-1.1
Domestic	(2)	b_1 to -78.28	120.819	-	118.649	-1.8	115.639	-4.3	111.506	-7.7	119.767	-0.9
Milk	(3)	b_2 to -21.34	120.799	-	118.435	-2.0	115.548	-4.3	110.325	-8.7	119.552	-1.0
Production	(4)	b_3 to 2.00	119.259	-	119.117	-0.12	116.744	-2.1	114.334	-4.1	118.650	-0.5
	(5)	b_1 to -78.28 & b_2 to 2.00	119.388	-	119.444	+0.04	117.120	-2.9	114.589	-4.0	118.992	-0.3
			$/cwt.	%Δ	$/cwt.	%Δ	$/cwt.	%Δ	$/cwt.	%Δ	$/cwt.	%Δ
Manufac-	(6)	None	4.58	-	4.79	+4.6	4.96	+8.3	5.88	+28.4	4.61	+0.7
turing	(7)	b_1 to -78.28	4.50		4.02	-10.7	4.13	-8.2	4.57	+1.6	4.03	-10.4
Milk	(8)	b_2 to -21.34	4.53		4.56	+0.7	4.70	+3.8	5.53	+22.1	4.43	-2.2
Price	(9)	b_3 to 2.00	4.69		4.69	0.0	4.76	+1.5	5.14	+9.6	4.73	+0.9
	(10)	b_1 to -78.28 & b_3 to 2.00	4.50		3.95	-12.2	3.98	-11.6	4.23	-6.0	4.08	-9.3
			$/cwt.	%Δ	$/cwt.	%Δ	$/cwt.	%Δ	$/cwt.	%Δ	$/cwt.	%Δ
	(11)	None	5.22	-	5.43	+4.0	5.62	+7.7	6.55	+25.5	5.25	+0.6
All	(12)	b_1 to -78.28	5.13		4.67	-9.0	4.80	-6.4	5.25	-2.3	4.68	-8.8
Milk	(13)	b_2 to -21.34	5.16		5.19	+0.6	5.35	+3.7	6.18	+19.8	5.06	-1.9
Price	(14)	b_3 to 2.00	5.33		5.33	0.0	5.41	+1.5	5.80	+8.8	5.37	+0.8
	(15)	b_1 to -78.28 & B_3 to 2.00	5.14		4.60	-10.5	4.64	-9.7	4.91	-4.5	4.73	-8.0

(%Δ) - Is the percent change from the Base Simulation for that variable brought about by the new price-support policy.

IV. SUMMARY AND CONCLUSIONS

The principle objective of this study was to evaluate how the dairy sector would have performed over the long-run under several alternative strategies of price change in the price support program. Because price-supports eliminate or at least substantially lessen the risk associated with random, unpredictable market prices for a commodity they also reduce the perceived costs of production to risk averse producers. In the long-run then, the effect of a price-support program is to lower market price by the cost of risk per unit of production. As a consequence, the support program may have delivered a lower equilibrium market price and larger production and consumption to society. The direct government cost of the program may be partially offset by this welfare gain to society. Costs associated with risk are not directly perceivable, yet they may be measured in terms of the loss in potential market production and the increase in prices resulting from an elimination of the price-support program.

A major hypothesis for our analysis was that the impact of price supports can be characterized by two elements. The first is the direct price effect, whereby a guaranteed price increases producers' expected prices. This has a positive effect on output and input use. Second is the effect on producers' perceived risk. Price supports create a more stable economic environment and should result in an additional positive output and input use change.

If producers' expectations play a crucial role in determining optimal production and input use and price supports modify these expectations, it becomes necessary for policy analysis to specify how this interaction occurs. The rational expectations hypothesis fulfills this need in an appealing manner. In a rational expectations framework producers expect prices to be given by the conditional expectations of the economic system within which they make their decisions. Thus, in modeling changes in exogenous policy variables such as the price-support level, the equations describing how producers formulate the expectation of that variable becomes an element in the economic model. Changes in the parameters of the producers' expectations model cause changes in the parameters describing the optimal economic behavior of dairy producers.

This research developed an econometric model incorporating risk factors and rational expectations by producers in adjusting to price support. The model contains nine equations and identities defining (i) capital capacity in milk productinn (ii) the level of milk production, (iii) the fluid milk demand curve, (iv) manufacturing milk demand curve, (v) the level of ending commercial stocks and (vi) the producers optimal price-support forecasting equation.

The capital capacity equation reveals that price supports do have a direct effect on capital stock. Dairy producers respond negatively to reductions in the risk of cash returns to crop production, which represents returns in an alternative economic activity, and positively to decreases in dairy price risks measured by the relative variability of dairy prices.

Using the estimated equations a policy evaluation model was constructed which allowed the comparison of a number of alternative price-support strategies that could have been followed. These were:

(i) a gradual decline in the price-support level, equivalent to a 1% per year reduction in the support level and a fall in the parity percentage from 80% to 21% over the period 1950-78;

(ii) a gradual decline of 2.5% per year and a parity reduction from 80% to 13% over the 1949-78 period;

(iii) a rapid decline in the price-support level from 1949 onward which virtually eliminated price supports within a very few years, and

(iv) the actual price support strategy from 1949 to 1965, then a gradual slowing of tne rate of price support increase from 1966 through 1978.

A number of important findings resulted from this analysis. First, it suggested that the price-support program can lead to market prices for both producer and consumers at levels equal to or below those which would have prevailed without the type of support policy actually followed. In the case of the gradual declining support levels it was shown that at the earliest market prices would have exceeded levels actual support induced levels by 1959, and would have remained higher for the remainder of the study period. The annual average blend price to producers would have been approximately 4 to 8 percent per cwt. higher for each year 1950-78. By 1978 the average price would have been from $1.98 to $2.40 per cwt. above those that actually occurred. Under the assumption of a rapidly declining price-support level, the model yielded market prices consistently higher than the actual dairy prices observed over the entire period. The utilization weighted average price in this case is approximately 25.5 percent per cwt. higher in each year. The alternative policy of slowing the annual rate of increase in the price-support from approximately 9.5 percent per year to 4.7 percent per year produced market prices which were higher by +0.6 percent per year over the actual support induced prices. This alternative policy eliminated price-support related purchases by 1971.

We conclude that with a reduction in the rate of increase in the price support level relative to the rate of increase in the parity price of milk, a "safety-net" type of program could have achieved reasonable levels of market prices and production without government support purchases by 1978. This program could have provided price-supports to avoid extreme declines in market prices, but with market prices usually determined by supply-demand equilibrium in the classical sense. Government support purchases would have declined to zero over the period 1971-1978.

The model used for evaluation was also useful in identifying the sensitivity of these conclusions to changes in supply and demand elasticities. For example, if manufacturing milk demand is twice as elastic as estimated in our model, then the average all milk price from reduced support would have been less than those that actually prevailed. Nevertheless, the general tendency for the market clearing price to rise toward and above the actual support price in the long-run still occurs, but at a much slower rate.

The analysis supports the hypothesis that dairy price supports reduce price risks. This risk reduction has shifted the milk supply function to the right and reduced cost of production. Reducing support prices either gradually or rapidly leads to a situation where no effective price protection exists. Once this point is reached, price risks increase, and the supply curve shifts back to the left. Thus, free market prices in the long-run may have been higher than those that prevailed under persistent and effective price support. This does not mean, however, that the lowering of price supports today will lead to immediate price increases. As evidenced in this study, gradual reductions in support price set economic forces at work which require 8 to 12 years to eliminate market dependency on federal support prices. There is no reason to doubt that if such policies were followed today similar time requirements would be required.

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NOTES

1. This specification of production as completely predetermined is based on the conceptual and practical argument that once dairy producers in aggregate have committed substantial capital resources in terms of cows and mechanical capital to the production of milk, such resources are fixed at least for the ensuing production period. It is recognized that some production flexibility is possible and is most likely responsive to current period market prices. The shift in supply due to this component is ignored in this model. For a model which takes an opposite view and suggests that all production is determined simultaneously with market prices, see Buxton, B., and J.W. Hammond (1974), "Social Cost of Alternative Dairy Price Support Levels," American Journal of Agricultural Economics, 56(2):286-291.

2. Conceptually the production of milk can be usefully characterized as a fixed-coefficient technology defined as $Q = M\ (C/a_c,\ K/a_k)$ where Q is milk production; C is all non-animal capital; K is the stock of dairy cows; and a_c, a_k are the respective input-output coefficients. Feed inputs are also fixed with respect to K. Under this formulation, aggregate milk production can be expressed as a function of animal units, properly adjusted for a time drift of the production surface away from a high animal to capital ratio and toward a low animal to capital ratio. For a more complete exposition of this point refer to the author's original dissertation, (Thraen, 1981).

3. There are alternative methods for handling this problem which are either explicitly or implicitly addressed and used in the literature. These include (i) specifying a vintage capital index, (ii) estimating equations for dairy animals and yields separately and determining aggregate production by the multiplicative identity $Q = K \cdot Y$, and (iii) estimating a generalized supply equation directly. The formulation adopted in this study was selected because it provides a useful approach to specifying the relationship between capacity to produce milk, represented by KC, and actual production. The method of adjustment is not ideal, however. It assumes that all biological and technological changes which have occurred in milk production can be captured in the yield per cow changes. It also assumes that changes in average yields are not substantially affected by short-run shifts in the application of variable inputs, such as feeds. When considering the fact that U.S. average milk yields have increased at a steady rate with very little year to year variability this assumption is most likely sufficient.

4. These criteria by Young represent a useful step toward providing an organized and objective method of evaluating empirical risk measures. However, the stated criteria are by no means the final word on the subject. For example, in criterion (i), why a mean-squared error as opposed to some other weighting?, or from criterion (vii), why is a plausible subjective expectations formulation deemed to be simple? I raise these questions only to point out the difficulty inherent in translating risk concepts into practice. An alternative definition of risk which draws a tight distinction between risk and uncertainty argues that unless the mechanism, i.e., the economic process which generates market prices, etc., is known with the same degree of certainty as we have with respect to a die or a coin, then the concepts of risk based on the probability calculus are no longer applicable because the producer operates in an economic environment characterized by uncertainty and not risk.

5. Note that in both the formulation of B and Z, gross rather than net returns are used. B is based on gross price received per hundredweight of milk, while cash returns to crop production is based on gross returns. More suitable measures would be to use net prices in each case. However, data limitations make it difficult to arrive at a useful measure of net price for either B or Z measures. To the extent that net returns have not fluctuated widely over the study period the use of gross prices is adequate. Given that the market price in dairy was primarily determined by the federal support price over the study period, a support price based on the production cost index, then for dairy, market price and net price are likely to be highly positively correlated over time. This may not be true for cash return to crop production.

6. The critical aspect here is whether or not the error terms in the producer's price-support forecasting equation are contemporaneously correlated with the error term in the demand for capital equation. The model was estimated using Zellner's joint three stage least squares with little gain in parameter covariance reduction or change in parameter values.

7. Note that in using all of the production years to estimate the parameters of the policy rules, we are utilizing some information which could not possibly be available to dairy producers. A justffication for this is to argue that dairy producers are superior at discerning the values of Θ for the different

regimes based on a limited number of observations than we are in an ex-post analysis. Admittedly this is a difficult problem, especially when there is a relatively short history of the policy rule to use. The only other alternative would be to refrain from any policy evaluation in the early years of the data base so as to give producers a sufficiently long period within which to form an approximation to the policy rule parameters.

8. This does not suggest that the model is not useful for the purpose at hand. As stated by Rausser, G. and E. Hochman (1980), "Dynamic Agricultural Systems: Economic Prediction and Control", North Holland, p. 12, "We have no option but to construct models that fall short of a complete specification of the system under examination....Hence it appears reasonable to suggest that (a) economic models can not be judged solely by the resemblence between their specification and the systems that they are designed to represent and (b) the choice of different model specification of the same system by different economists implies no presumption that one of them must be in error. For these reasons, it is safer to investigate the "sufficiency" of models rather than their "realism;" in other words, is the constructed model, for the purposes designed, adequately sufficient?" The model developed in this study has to be our representation of reality, including its error. Therefore, it is only reasonable to compare any deterministic changes made by the researcher against the models representation of reality and not against reality itself.

9. The Theil Inequality Coefficient quantitatively measures the ability of the econometric model to replicate the behavior of the actual data series. This coefficient and its application is described in detail in Maddala, 1979.

10. Parity price for milk is defined as the price which maintains the same purchasing power of milk in terms of goods and services purchased by farmers that prevailed in the period, 1910-14.