Resolving Dairy Market Disequilibrium: Forecasting the Simple Answers to Simple Questions

by

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Forecasting the Simple Answers to Simple Questions

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One problem currently facing the dairy industry is U.S. government net expenditures for surplus dairy products in the 1982-83 fiscal year were \$2.5 billion which purchased dairy products equivalent to 16.6 billion pounds of milk. Figure 1 plots historical production and nongovernmental utilization of milk from 1954 thru 1983 on a calendar year basis. In this figure, the difference between production and nongovernmental utilization is primarily milk price support purchases on a milk equivalent basis. This figure shows that by historical standards, price support purchases are currently quite large both in absolute and in relative terms. Milk production during the 1982-83 fiscal year, which also corresponds to the dairy marketing year, was 138.1 billion pounds while the dairy price support program removed twelve percent of this total. Further, the \$2.5 billion government expenditure for these products was over four times the target expenditure level of \$600 million. In a political climate dominated by discussion of budget deficits, dairy price support programs are being seriously questioned.

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*The author is an Assistant Professor of Economics at Iowa State University where this research was performed under project 2669 of the Iowa Agricultural Experiment Station and North Central Regional Research Project NC-176.

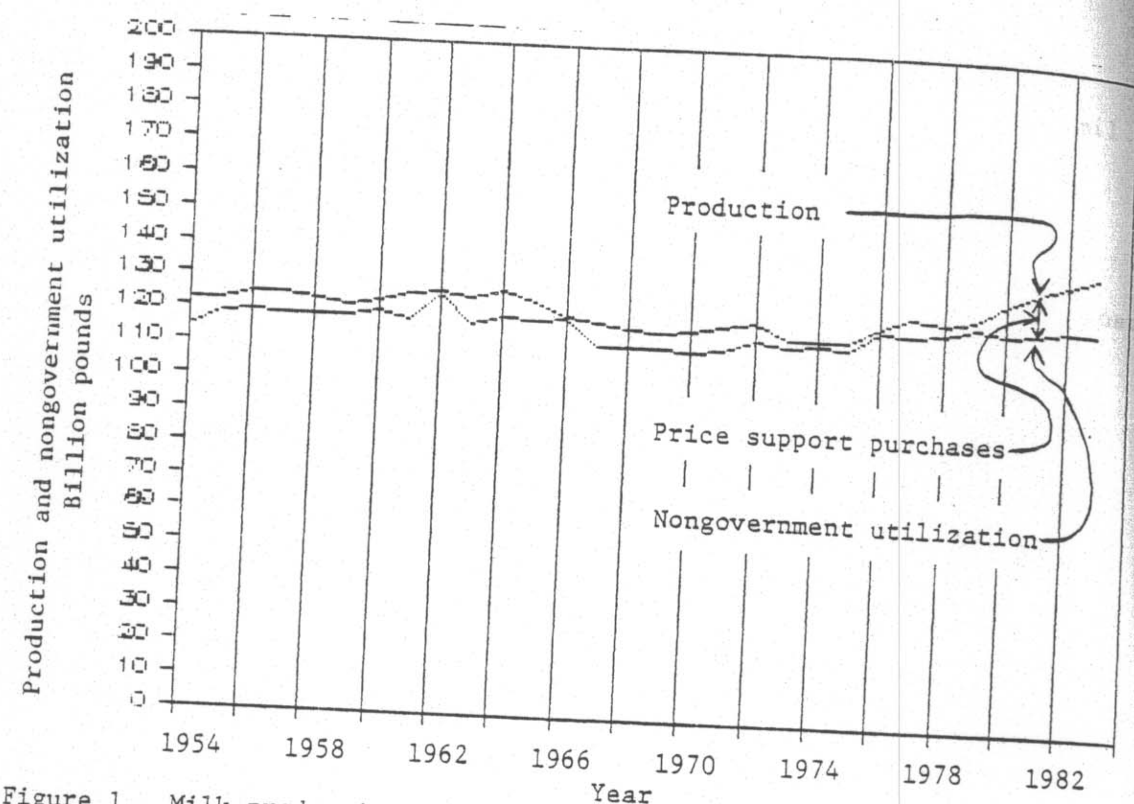

Figure 1. Milk production and nongovernment milk utilization, 1954-83.

Milk price supports at the farm level began during the Second World War. The mechanism for support price determination has passed through three phases and is currently in the fourth phase. The first phase of milk support price determination was institutionalized in the Agricultural Act of 1949 which directed the Secretary of Agriculture to set the support price for milk in the range of 75 to 90 percent of parity. These percentage-of-parity support price ranges for milk have survived numerous revisions of U.S. agricultural policy although the lower limit has been temporarily increased from 75 percent on four different occasions.

In phase II, initiated with the passage of the Agricultural and Food Act of 1981, the support price determination rules were disconnected from parity. In reponse to milk surplusses that were large by historical standards, this act specified a set of support price triggers that were dependent on the size of CCC purchases. As long as CCC purchases remained large, the support price was frozen at the 1980-81 level of $13.10 per hundredweight. The support price remained frozen at $13.10 for nearly two years except for twenty days in October of 1982.

Phase III of milk support price determination occurred with the passage of the Omnibus Budget Reconcilation Act in September of 1982 which gave authority to the Secretary of Agriculture to implement producer assessments. These producer assessments were used to partially offset the cost of the support program. On April 16, 1983, an assessment of $0.50 per hundredweight was imposed on all milk marketed. Later, on September 1, 1983 an additional $0.50 per hundredweight assessment was imposed. This second assessment was refunded to those producers who reduced their milk marketings by 11.6 percent from their average marketings during the 1980-81 and 1981-82 marketing years.

Phase IV, the Dairy and Tobacco Adjustment Act of 1983, began in response to further milk surplusses in 1983. Beginning January 1, 1984 and lasting for fifteen months, this act provides for (1) a \$10 per hundredweight diversion payment for those producers who reduce their marketings from five the thirty percent of their base period's marketings, (2) a fifty cent per hundredweight reduction in the support price from \$13.10 to \$12.60 per hundredweight, (3) a single fifty cent per hundredweight assessment to help finance the price support program and (4) a fifteen cent per hundredweight milk advertising and promotion assessment.

The purpose of this paper is to examine the impact of various dairy policies on near- and long-term milk production, to examine whether dairy price support purchases will be reduced when milk markets are confronted with the present set of prices, and if needed, to determine a set of prices under which a regulated quasiequilibrium will prevail in the market for milk.

Theoretical Model

Dairy policy actions and reactions were designed to manipulate milk production. A model of aggregate U.S. milk supply will therefore be used to analyze the impact of alternative past and present milk price support policies. The model consists of the following equations.

$$\ln XFD_t'^* = \beta_{10} + \beta_{11} \ln(\frac{PFD}{PRC})_t + \beta_{12} \ln(\frac{PAV}{PRC})_t + \beta_{13} t + u_{1,t} \qquad (1)$$

$$\ln QT_t'^* = \beta_{20} + \beta_{21} \ln(\frac{PFD}{PRC})_t + \beta_{22} \ln(\frac{PAV}{PRC})_t + \beta_{23} t + u_{2,t} \qquad (2)$$

$$\ln XFD'_t - \ln XFD'_{t-1} = \beta_{30}\ (\ln XFD'^{*}_t - \ln XFD'_{t-1}) \quad (3)$$

$$\ln QT'_t - \ln QT'_{t-1} = \beta_{40}\ (\ln QT'^{*}_t - \ln QT'_{t-1}) \quad (4)$$

$$\ln XCW'_t - \ln XCW'_{t-3} = \beta_{50} + \beta_{51}\ [\ln(\frac{PCW}{PRC})_{t-3} + \ln(\frac{PCW}{PRC})_{t-2} + \ln(\frac{PCW}{PRC})_{t-1} + \ln(\frac{PCW}{PRC})_t] + \beta_{52}\ [\ln(\frac{PCV}{PRC})_{t-2} + \ln(\frac{PSH}{PRC})_{t-1} + \ln(\frac{PCL}{PRC})_t] + u_{5,t} \quad (5)$$

$$\ln(\frac{PCW}{PRC})_t = \beta_{60} + \beta_{61}\ \ln(\frac{PAV}{PFD})^{*}_t + \beta_{62}\ t + u_{6,t} \quad (6)$$

$$\ln(\frac{PAV}{PFD})^{*}_t - \ln(\frac{PAV}{PFD})^{*}_{t-1} = \beta_{70}\ [\ln(\frac{PAV}{PFD})_{t-1} - \ln(\frac{PAV}{PFD})^{*}_{t-1}] \quad (7)$$

$$\ln XFD'_t = \ln XFD_t - \ln XCW_t - \ln(1000) \quad (8)$$

$$\ln QT'_t = \ln QT_t - \ln XCW_t - \ln(1000) \quad (9)$$

where [1]

PAV_t = average price received by farmers for all milk in year t ($/cwt),

PCL_t = price received by farmers for cull dairy cows sold for slaughter in year t ($/cwt),

PCV_t = price received by farmers for calves sold for slaughter in year t ($/cwt),

PCW_t = price received by farmers for dairy cows that are producing in year t ($/cwt),

PFD_t = price paid by farmers for 16% dairy ration in year t ($/cwt),

PRC_t = index of prices received by farmers in year t (1967 = 1.00),

PSH_t = price received by farmers for steers and heifers sold for slaughter in year t ($/cwt),

QT_t = total milk production in year t (million lbs),

QT'_t = total milk production per dairy cow in year t (lbs),

$QT^{*\prime}_t$ = optimal level of milk production per dairy cow in year t (lbs),

t = year less 1900,

XCW_t = number of dairy cows in year t (thousand head),

XFD_t = total feed consumed by dairy cows in year t (million lbs),

XFD'_t = feed consumed per dairy cow in year t (lbs),

$XFD^{*\prime}_t$ = optimal level of feed consumption per dairy cow in year t (thousand lbs), and

$(PAV/PFD)^*_t$ = expected milk-feed price ratio in year t.

This model can be divided into subsectors consisting of (1) thru (4), (5) thru (7) and the identities (8) and (9). Equations (1) and (2) model production per cow and feed fed per cow, respectively, while (3) and (4) are the respective partial adjustment models. Equation (5) models the supply of dairy cows as adjustments in dairy cow stocks. Equation (6) models the infinitely elastic demand for dairy cows by capitalizing milk and feed prices into dairy cow prices via (7), an adaptive expectations model of the milk--feed price ratio.

Empirical Results

The model was estimated using U.S. annual data from 1954 thru 1978. These data were available in various issues of Agricultural Statistics, Dairy Outlook and Situation and Agricultural Prices. The estimation results are summarized in Table 1.

The per cow feed demand and milk supply functions were jointly estimated using restricted three stage least squares. This estimation technique was judged to be appropriate since (a) the average price of milk received by farmers is endogenous to a complete supply-demand model and so it was treated as an endogenous variable in estimating this model, (b) the coefficients of adjustment in (3) and (4) are hypothesized to reflect the

Table 1. Results of estimating the reduced forms of equations (1) thru (9).[a]

Equation	Estimators	R^2	MSE	DFE	DW	$\hat{\beta}(1)$
Feed demand per cow $\ln XFD'_t = \underset{(0.2076)}{1.2959} + \underset{(0.07085)}{0.7813} \ln XFD'_{t-1} \underset{(0.07136)}{-0.2393} \ln(PFD/PRC)_t + \underset{(0.06586)}{0.1702} \ln(PAV/PRC)_t + \underset{(0.003217)}{0.007688}\, t$						
Milk supply per cow $\ln QT'_t = \underset{(0.03898)}{1.5378} + \underset{(0.07085)}{0.7813} \ln QT'_{t-1} \underset{(0.01655)}{-0.04277} \ln(PFD/PRC)_t + \underset{(0.03345)}{0.1154} \ln(PAV/PRC)_t + \underset{(0.002092)}{0.005049}\, t$	R3SLS	0.9962	1.2700	40		
Milk price capitalization into dairy cow prices $\ln(PCW/PRC)_t = \underset{(0.1303)}{4.379} + \underset{(0.1644)}{1.242} \ln(PAV/PFD)_{t-1} + \underset{(0.002369)}{0.009512}\, t$	OLS	0.8911	0.004119	21	1.3242[b]	
Dairy cow stock adjustment $\ln XCW_t - \ln XCW_{t-3} = -0.6877 + \underset{(0.02066)}{0.05493} \sum_{i=0}^{3} \ln(PCW/PRC)_{t-i}$ $\underset{(0.02374)}{-0.06670} [\ln(PCL/PRC)_t + \ln(PSH/PRC)_{t-1} + \ln(PCV/PRC)_{t-2}]$	GLS	0.3303	0.0003590	18		0.7740

[a]Standard errors are indicated in parentheses.

[b]Insignificant first order autoregressive coefficient.

single adjustment of farmers' feeding rates and were hypothesized to be equal and, (c) profit maximization on the part of dairy farmers implies a hypothesized symmetry restriction that exists across equations (1) and (2).[2] The test of the null hypothesis of equal coefficients of adjustment in (3) and (4) resulted in an F statistic with a probability of a larger value of 0.47 and could therefore not be rejected. The test of the null hypothesis of symmetry in the milk supply and feed demand equations resulted in a probability of a larger F statistic of 0.56 and likewise could not be rejected. A joint test of these two hypotheses was also not rejected since the probability of a larger F was 0.71. Therefore, the restricted estimation seems consistant with the data. The hypotheses that dairy farmers never adjust feeding rates and that dairy farmers instantaneously adjust feeding rates were both rejected at the five percent significance level. Finally, Table 1 shows that all of the estimated coefficients in the feed demand and milk supply functions are of the correct sign and most are significantly different from zero.

The dairy cow price and dairy cow stock adjustment equations serve to explain dairy cow stocks in this model. Initial estimates of the dairy cow stock equation resulted in parameter estimates on lagged cow numbers that were greater than but not significantly different from one. These initial estimates also suggested significant serial correlation in the residuals of this equation. As a result, adjustments in the dairy herd were modeled rather than the dairy herd size.[3] One result is lower R^2's than would result from modeling the absolute size of the dairy herd. The dairy cow stock adjustment equation has an R^2 of 0.3303 and explains 98 percent of the variation in the absolute level of dairy cow stocks. The estimated parameters are all of the correct sign and are significant at the five percent or greater level. The residuals in this model follow a first order autoregressive process with a serial correlation of 0.77.

The milk price capitalization model explains 89 percent of the variation in the real price of cows. This model is derived from the reduced form of (6) and (7) after the null hypothesis that $\beta_{70} = 1$ could not be rejected. All of the estimated parameters are of the correct sign and are significant at the five percent or greater level.

Figure 2 is an alternative representation of the empirical results in Table 1. This figure plots of the dynamic elasticities of dairy cow stocks, production per cow and total milk production each with respect to the average milk price received by farmers. In normal supply elasticity computations, the numerator of the elasticity is the percentage change in quantity supplied between period t and period t+k (k > 0). With a dynamic model as described here, the quantity produced is time dependent in the absence of a price change. The base for the percentage change in quantity in the numerator of the dynamic elasticity is the quantity that would have been produced at time t+k if a price change had not occurred at time t.[4] Figure 2c shows that ten years after a one percent increase in the price of milk received by farmers, the quantity of milk supplied will be 1.5 percent larger than it would have been if price had not been increased ten years previously.[5]

It is also of interest to compare the elasticities plotted in Figure 2 with the elasticities reported in Table 2 which were estimated by previous

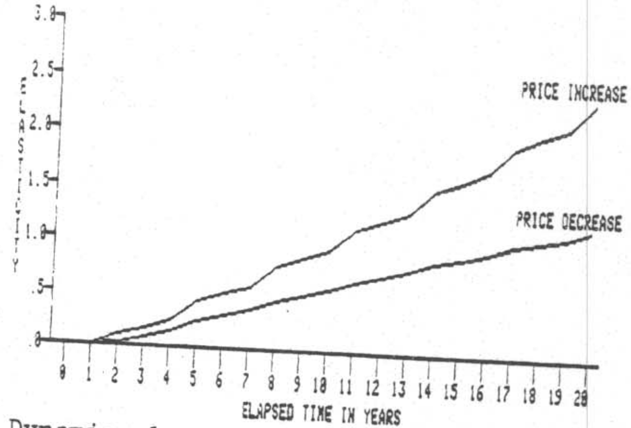

Fig. 2a. Dynamic elasticity of dairy cow stocks with respect to milk prices.

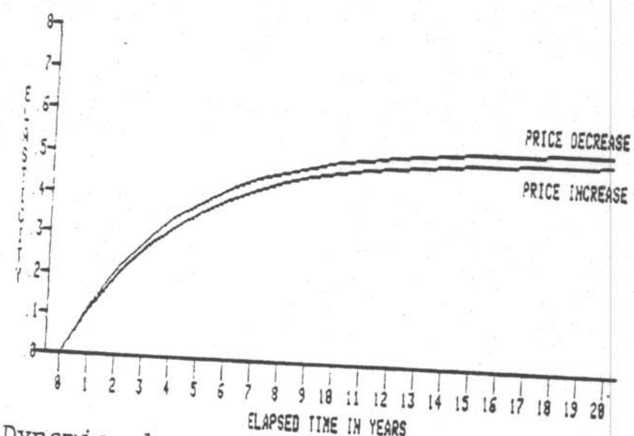

Fig. 2b. Dynamic elasticity of milk production per cow with respect to milk prices.

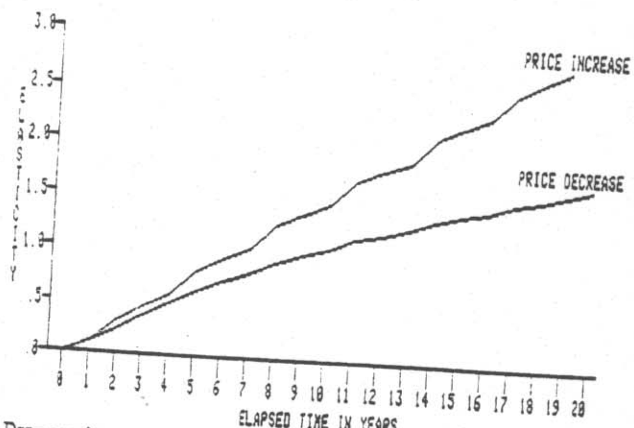

Fig. 2c. Dynamic elasticity of total milk production with respect to milk prices.

Figure 2. Decomposition of the dynamic elasticity of total milk production with respect to an increase and a decrease in milk prices.

Table 2. Summary of supply elasticities estimated in other studies.

Author	Data	Dependent Variable	Elasticity w.r.t. Milk Prices
Brandow	1933-51 semiannual for PA, NY, WI, MN	production per cow	0.04-0.18
Halvorson (1955)	1931-54 semiannual regional	production per cow	0.00-0.22
Halvorson (1958)	1927-57 annual	total milk production	0.16-0.18 short run 0.40-0.44 long run
	1941-57 annual	total milk production	0.29-0.31 short run 0.50-0.90 long run
Cochrane	1947-56 annual	total milk production	0.03
Wipf & Houck	1945-64 annual	total milk production	0.04-0.07 short run 0.06-0.16 long run
Chen, et.al.	1953-68 quarterly for California	total milk production	0.38 short run 2.54 long run
Wilson and Thompson	1947-63 annual	total milk production	0.003 short run 0.52 long run
Pareto	1950-68 annual	total milk production	0.006 short run 0.007 long run

researchers. Table 2 and Figure 2 both show a very inelastic price response of milk production in the short run. In an infinitely long run, the elasticity estimated by the model is infinity due to the infinite elasticity of dairy cow stocks with respect to the milk price. In a long run of sixteen years, which corresponds to two complete life cycles of the dairy herd, the price elasticity of milk supply shown in Figure 2 is about 2.5 for a price increase and 1.5 for a price decrease. These long run supply elasticities exceed all but the greatest long-run elasticities reported in Table 2.

Policy Implications

This model can be used to examine and in some cases compare the time path of adjustment for milk production and nongovernmental utilization in response to imposing alternative policies on U.S. milk markets. In all cases, the independent variables are the same except for the average price of milk received by farmers. This price is dependent on policy variables such as the level of the support price and/or producer assessments. Based on their trending behavior during the 1980-83 time period, the price of feed, price of cull cows, price of steers and heifers and the index of prices received by farmers are assumed to remain at their 1983 levels through 1990. This assumption holds all real prices constant at 1983 levels except for milk where dairy policy actions are assumed to fix nominal milk prices.

Dairy policy alternatives which change the support price will in turn alter the price processors pay as well as the price farmers receive for raw milk. For these analyses, it is assumed that movements in the support price will result in equal movements in the average milk price received by farmers since the price support is effective and since it undergirds the entire classified pricing system. It is also assumed that the elasticity of milk demand is -0.50 so that the policy actions that lower milk support prices will tend to stimulate milk consumption. Using these assumptions, simple questions can be asked of the simple model which will give simple answers.

Question 1. As discussed previously, producer assessments of $0.50 per hundredweight were imposed on all milk marketed beginning April 16, 1983 with an additional assessment being imposed beginning September 1, 1983. The first question is, "What would have happened to milk price support purchases had these assessments not been imposed and had no other policy actions been taken in 1983?" Figure 3 provides a simple answer to this question. This figure shows that milk price support purchases would have gotten even larger thru 1990. Alternatively stated, had no policy actions been taken in 1983, milk markets would have gotten more severely out of equilibrium as time went on.

Question 2. Since producer assessments were implemented in 1983, a second question is "What would have been the impact of these assessments, totaling $1.00 per hundredweight, if they had been retained in their 1983 form in 1984 and beyond?" Figure 3 shows that the assessments were effective in substantially reducing the volume of price support purchases even though substantial price support purchases would have continued to exist through 1990.

Question 3. The system relying on producer assessments was replaced with a paid diversion in 1984. The question is "What is the best that this program can hope to accomplish?" Under the paid diversion program the reduction of the support price is projected to stimulate commercial utilization as well as to reduce supplies eventually. Once the initial adjustments take place, the new price signals will either move the milk markets toward or away from equilibrium. Figure 4 shows that if the paid diversion achieved culling and feeding rate changes such that long-run equilibrium levels prevailed in 1984, the current set of prices would essentially keep the market in equilibrium through 1990. This figure assumes that feeding

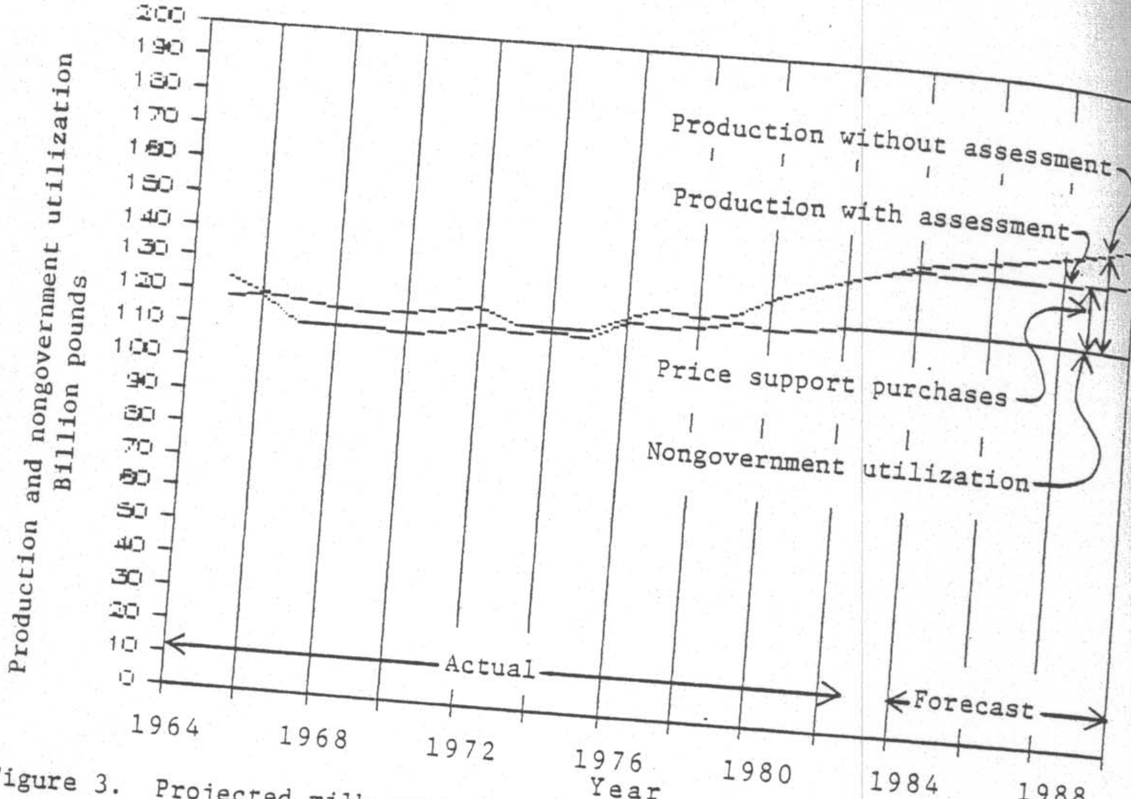

Figure 3. Projected milk production and nongovernment milk utilization with and without the 1983 producer assessments.

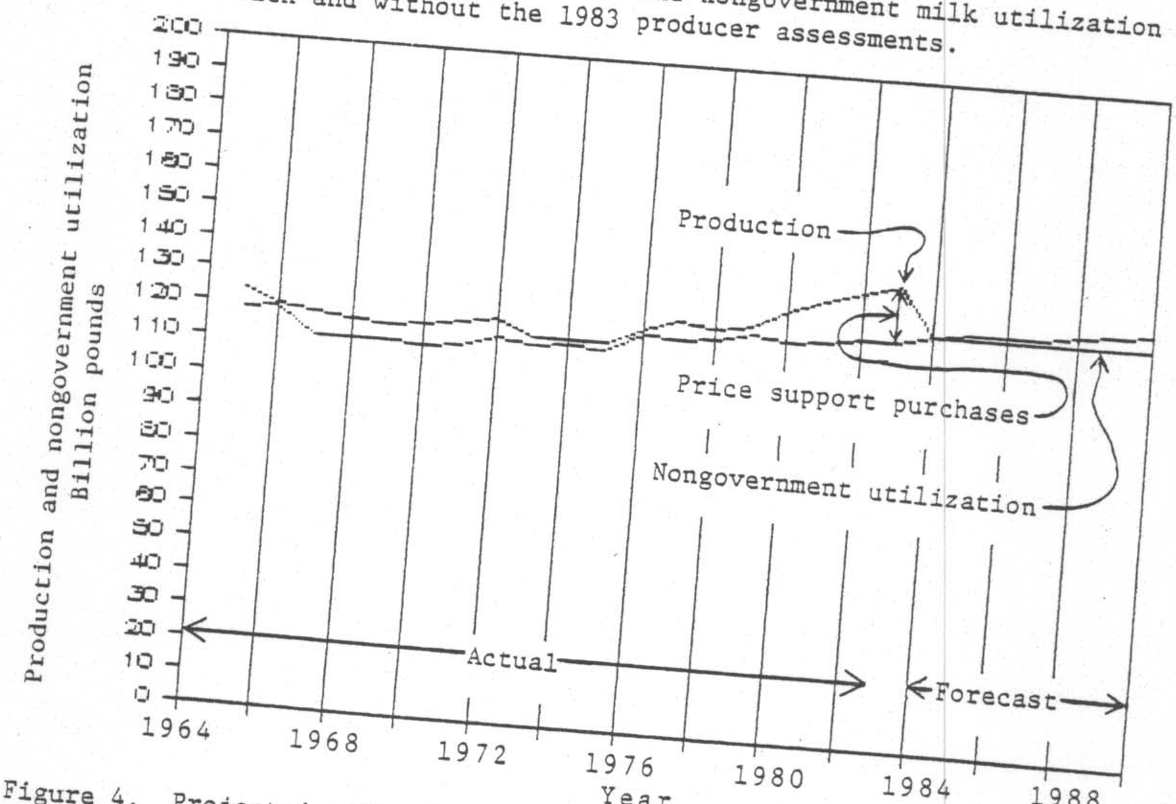

Figure 4. Projected milk production and nongovernment milk utilization with a completely effective paid diversion program in 1984.

rates instantaneously adjust to long-run equilibrium levels and dairy cow cullings are such that price support purchases are eliminated in 1984.

Question 4. Part of the signup procedure for the paid diversion program required that producers provide information on how production was going to be cut on each participating dairy farm. Initial analysis of these data by Boynton and Novakovic suggests that 342,000 dairy cows will be culled from dairy herds in addition to normal cullings in 1984. Boynton and Novakovic further anticipate 138.5 billion pounds of milk produced in 1984. A fourth question is "What effect will the paid diversion program of 1984 have on milk price support purchases in 1985 and beyond?" Figure 5 shows that the paid diversion program will be successful in freezing the level of price support purchases but it does not result in the liquidation of a large enough component of the dairy herd nor are prices low enough coming out of the paid diversion program to drive price support purchases to insignificant levels. It should also be noted that this projection assumes that the paid diversion program has no exogenous impact on the proportion of replacement heifers that are kept for dairy herd additions in 1985 or 1986.

Question 5. Since support prices under the paid diversion program are not low enough to reduce significantly the amount of price support purchases, a natural question is "How much should the support price be reduced to bring dairy markets to near equilibrium levels in the not too distant future?" Figure 6 traces production and nongovernmental utilization assuming the support price is cut by $1.50 per hundredweight in 1985. This leaves the support price at $11.10 per hundredweight. It is interesting to

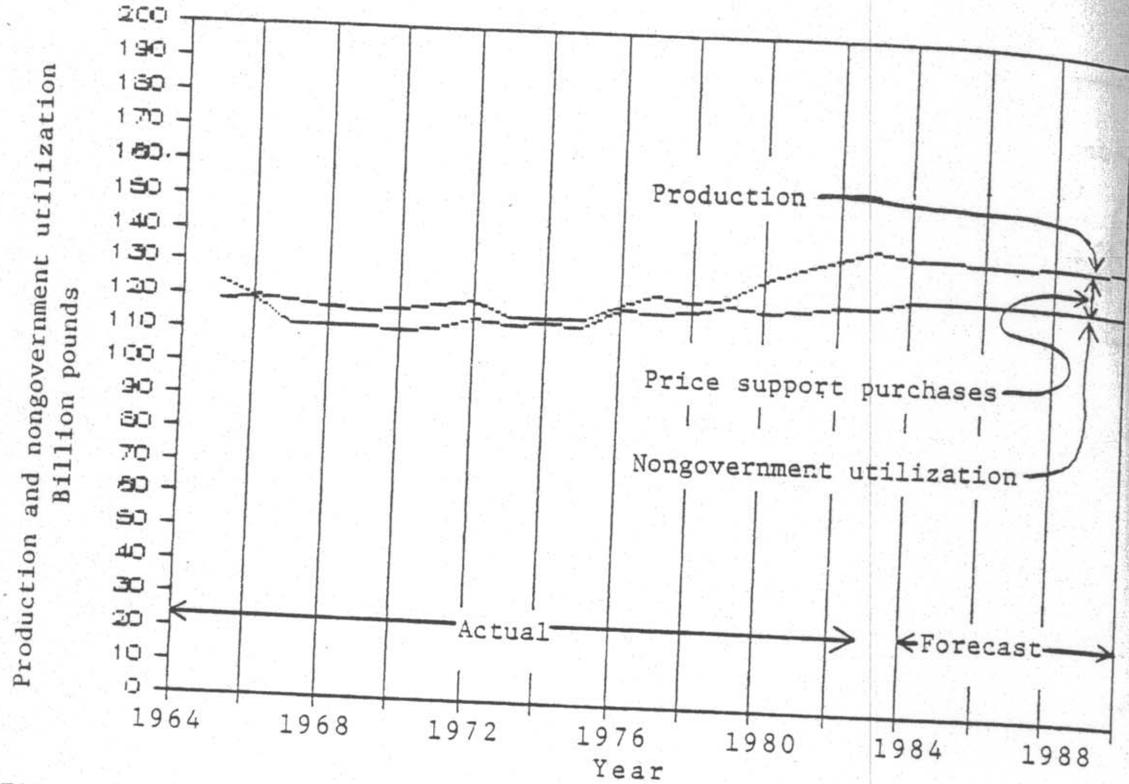

Figure 5. Projected milk production and nongovernment milk utilization with the likely paid diversion program effect in 1984.

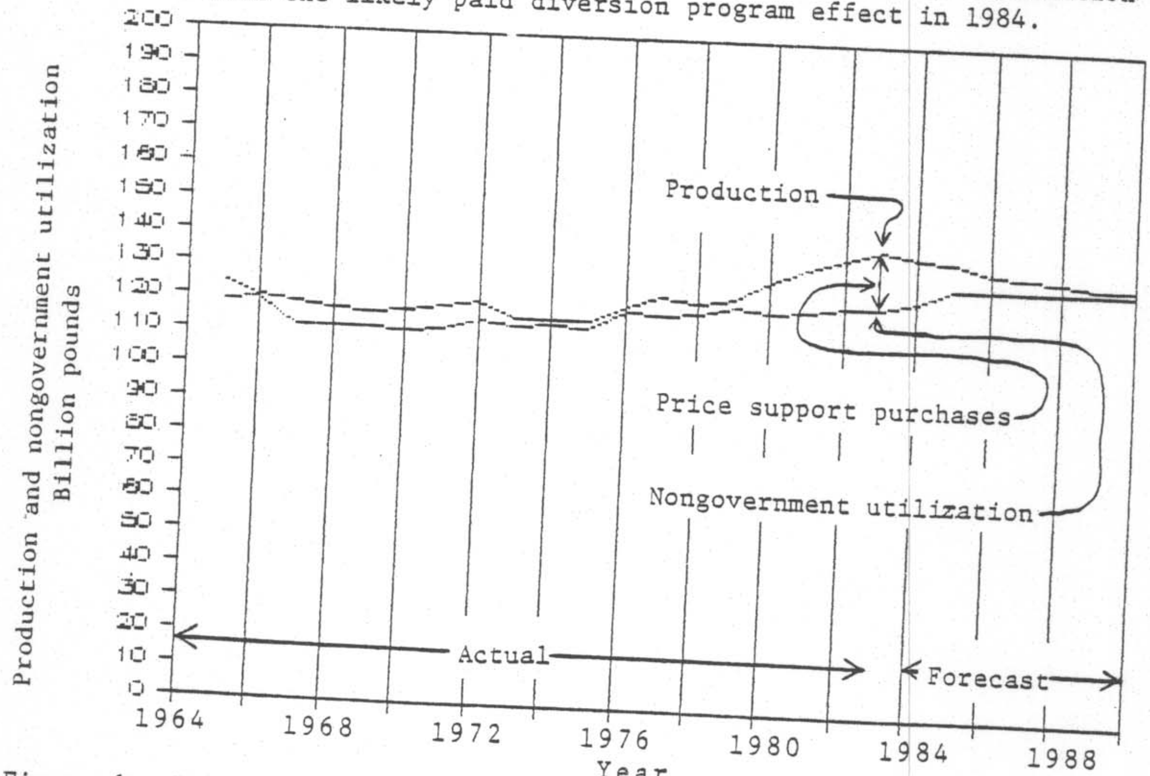

Figure 6. Projected milk production and nongovernment milk utilization with a $1.50/cwt cut in the support price in 1985.

note that according to Figure 6, milk markets will attain a regulated equilibrium in 1990. Equally important, however, is that in 1990 when dairy markets appear to be in equilibrium, forces will already be in motion which will cause a milk supply deficit that will drive up milk and dairy product prices. Therefore, stability of dairy prices will require that the support price be increased when milk production is headed for equilibrium rather than when milk supply deficits appear. Also implicit in Figure 6 is that even though milk markets reach equilibrium by 1990, there are substantial price support purchases between 1984 and 1990. These purchases imply that CCC stocks will remain sizable and continue to increase thru 1990 unless an efficient donation program is undertaken.

Question 6. One feature of the forecasts reported thus far is the absence of the impact of inflation on milk price support purchases. A final question asked of this model is "Given the impact of the paid diversion program in 1984, what will be the impact of inflation on forecast dairy price support purchases?" Simulations indicate that should prices in the agricultural economy start increasing at an annual rate of five percent, dairying will become less profitable and milk price support purchases will fall dramatically starting in 1985 and a deficit would exist by 1990 even without the paid diversion program and without a support price reduction from $13.10 per hundredweight. In general, inflation in either consumer prices or agricultural prices will cause a milk deficit to develop more quickly than in an inflation free environment as the real price of dairy products falls along with the real price of milk at the farm level.

Summary and Conclusions

The results of this study indicate that the price elasticity of milk production in a one year period is 0.11. This inelastic short-run supply response is not drastically different from results found by other researchers. Contrary to the results found by other researchers, the price elasticity of milk supply becomes elastic after seven years for a price increase and after nine years for a price decrease. In the infinitely long run, the elasticity of supply of this model is infinity but it takes more than twenty years of cumulative effects before the elasticity exceeds 3.0. The elasticities estimated in this study exceed the elasticities estimated by other researchers except for the most elastic supply response estimates.

The apparent irreversibility of the supply response in this model is due to underlying technical change rather than due to "asset fixity". In a dynamic model, such as this one, the separation of technical change and the long-run impact of a price change cannot be achieved. Thus, in the evaluation of a long-run impact of a price change, underlying technical change tends to either reinforce or diminish the impact of the price change. This causes the supply response to appear to be irreversible.

The dynamic characteristics of the supply response is especially important for policy analysis. The structure reported in Table 1 implies that disequilibrating effects of dairy policy take a long time to develop and likewise, appropriately planned and executed policies take a long time to achieve their desired effects. Especially frustrating from a policy stand point is the appearance of approaching equilibrium which is soon replaced by deepening disequilibrium.

FOOTNOTES

[1]These variable names are arranged in alphabetical order and the convention used is that $(PAV/PFD)^{*}_{t} = (PAV^{*}_{t}/PFD^{*}_{t})$.

[2]Symmetry requires that $-\frac{\partial XFD^{*\prime}}{\partial PAV} = \frac{\partial QT^{*\prime}}{\partial PFD}$. A linear approximation of this restriction is $0.2504\beta_{12} = -0.9963\beta_{21}$. This restriction was derived under the assumptions of (a) equal coefficients of adjustment, i.e. $\beta_{30} = \beta_{40}$, (b) exponential growth in the average product of feed and (c) a constant cost share for feed.

[3]The hypothesis that year-to-year adjustments of dairy cow stocks due to culling decisions are different from long-run dairy herd replacement decisions, was tested by modeling the year-to-year adjustment of dairy cow stocks. Though not reported here, this model specified year-to-year changes in the stock of dairy cows as a function of the ratio of the contemporaneous price of dairy cows deflated by the contemporaneous index of prices received by farmers and the ratio of the contemporaneous price of cull dairy cows deflated by the contemporaneous index of prices received by farmers. Since the price elasticities for the year-to-year adjustment were not significantly different from the corresponding elasticities for the three year adjustment, it was concluded that the year-to-year adjustment is part of the three year longer-run adjustment process.

[4]The elasticities shown in Figure 2 were computed by performing a baseline simulation using the means of the independent variables. A second simulation was performed where the model was subjected to a permanent ten percent increase in the average price of milk received by farmers at year zero. In yet a third simulation, the model was subjected to a permanent ten percent price decrease at year zero. The dynamic elasticities were computed by comparing the quantity of milk produced in the second and third simulations with the quantity of milk produced in the same time period in the baseline simulation.

[5]Since the entire model is linear in the logarithums of the data, these elasticitites are constant, irrespective of the magnitude of the percentage change in price.

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