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An Analysis of Alternatives to the Dairy Price Support Program

by

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Abstract

The U.S. dairy industry has operated under a price support program since 1949. Between 1949 and 1980, the dairy price support program generally operated without incurring large government costs and was an effective price stabilizer. However, since 1980, the dairy industry has experienced chronic excess production relative to consumption and consequently government purchases under the price support program have been excessively large (particularly in the mid-1980s). The tremendous increase in government costs of the dairy price support program and a growing dissatisfaction with the program by farmers has prompted proposals to modify or replace this program.

This paper examines the potential market impacts of five different dairy policy scenarios. The five policies are: (1) a baseline price support program scenario, (2) an immediate deregulation scenario where the price support program is eliminated, (3) a gradual deregulation scenario where the support prices for dairy products are decreased by 10% per year, (4) a target price-deficiency payment program scenario, and (5) a mandatory supply control program scenario. A model of the national dairy industry is used to simulate quarterly equilibrium price and quantity values at the farm and wholesale levels for each policy over the period 1980-90.

The results indicate that there are gainers and losers for each policy option. Consumers are better off under the deficiency payment program and both deregulation scenarios because prices are lower, which enables them to consume more dairy products. On the other hand, consumer are worse off under supply control where, with the exception of butter, wholesale prices are at their highest. Farmers, as a group, are better off under the supply control and deficiency programs. Farm milk prices and producer surplus are highest under these two policies. Producers suffer the most in the immediate deregulation scenario

where both the farm price and producer surplus are at their lowest levels. Tax payers are best off under immediate deregulation and supply control, while substantially worse off under the deficiency payment program. These results suggest that the relative political weight that politicians give to consumers, farmers, and tax payers will be quite important in shaping future dairy policy legislation.

An Analysis of Alternatives to the Dairy Price Support Program

Harry M. Kaiser

The U.S. dairy industry has operated under a price support program since 1949. The purpose of the program is to stabilize dairy farmer income and lessen the seasonal instability in milk prices. Under the program, the government indirectly supports the farm milk price by offering to purchase unlimited quantities of storable manufactured dairy products at specified purchase prices. The government thus attempts to maintain the market price for raw milk at or near the support price by increasing the farm demand for raw milk.

Between 1949 and 1980, the dairy price support program generally operated without incurring large government costs and was an effective price stabilizer (Bausell, Belsley, and Smith). However, since 1980, the dairy industry has experienced chronic excess production relative to consumption and consequently government purchases under the price support program have been excessively large (particularly in the mid-1980s). The result has been an increase in net monetary outlays for the dairy price support program, which have risen from an annual average of $244.3 million for FY 1977-79 to an annual average of $1.67 billion for FY 1980-89 (U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service). The tremendous increase in government costs of the dairy price support program and a growing dissatisfaction with the program by farmers has prompted proposals to modify or replace this program. For example, in June 1993 members of the Clinton Administration and Congress held a Dairy Summit in Pennsylvania to discuss alternatives to the current program that would both help farmers and lower government costs.

The purpose of this paper is to investigate the market impacts of several alternative federal dairy policies to the dairy price support program. The policy scenarios investigated include: (1) a baseline price support program scenario, (2) a deregulation scenario where the price support program is immediately eliminated, (3) a gradual deregulation scenario where the support prices for dairy products are decreased by 10% per year, (4) a target price-deficiency payment program scenario, and (5) a mandatory supply control program scenario. Each one of the dairy policies considered has been discussed by some policy and dairy industry leaders in the past as an alternative to the existing program. However, most recent research has focused on deregulation (LaFrance and de Gorter), voluntary supply control (Dixon, Susanto, and Berry; Bausell, Belsley, and Smith), or mandatory supply control (Kaiser, Streeter, and Liu) in isolation of one another.

The analysis is based on a quarterly-dynamic econometric-simulation model of the dairy industry that includes wholesale and farm markets. The model is used to simulate quarterly equilibrium prices and quantities for each policy scenario. The simulation of the five policy scenarios is conducted in the sample period from the first quarter of 1980 through the fourth quarter of 1990. An in-sample simulation of the 1980s is conducted because this was a time when there was a lot of discussion about replacing, or modifying the price support program. In addition, the exogenous variables do not have to be forecasted for an in-sample simulation.

Conceptual Model

The model divides the dairy industry into a wholesale and farm sector. The retail sector is excluded because available national consumption data are commercial disappearance estimates at the wholesale rather than retail level. It is assumed that farmers produce Grade A (fluid eligible) milk and sell it to dairy wholesalers. There are four types of wholesalers represented in the model: fluid milk, frozen dairy products, cheese, and butter manufacturers.[1]

There currently are two major federal programs that regulate the dairy industry: federal milk marketing orders and the dairy price support program. The federal order program is

[1]Fluid milk, frozen products, cheese, and butter are expressed on a milkfat equivalent basis in the model. Since all quantities are expressed on a milkfat basis, nonfat dry milk is not included in the model.

included in all five policy scenarios and it is assumed that milk handlers are regulated under a single federal milk marketing order. The national federal order is captured in the model by constraining the prices wholesalers pay for raw milk to be the minimum class prices. Fluid milk wholesalers are required to pay the higher Class I price, while cheese, butter, and frozen product wholesalers pay the lower Class II price.[2] The dairy price support program is included in the baseline and the gradual deregulation policy scenarios, but is eliminated in the immediate deregulation, deficiency payment, and supply control scenarios. This program is incorporated into the model by constraining the wholesale market cheese and butter prices to be greater-than-or-equal-to the government purchase prices. Since the government is willing to purchase unlimited quantities of these products at the announced purchase prices, the program indirectly supports the farm milk price by increasing farm level milk demand.

The wholesale market for the four dairy products is defined by a set of supply and demand functions and equilibrium conditions that require supply to be equal to demand. The wholesale fluid milk and frozen product markets have the following specification:

(1.1) $Q^{wd} = f(P^{w}|S^{wd})$,

(1.2) $Q^{ws} = f(P^{w}|S^{ws})$,

(1.3) $Q^{ws} = Q^{wd}$,

where: Q^{wd} and Q^{ws} are wholesale demand and supply, respectively, P^{w} is the wholesale own price, S^{wd} is a vector of wholesale demand shifters, and S^{ws} is a vector of wholesale supply shifters. The vector of shifters for the wholesale fluid milk supply function includes the Class I price, which is equal to the Class II milk price (i.e., the Minnesota-Wisconsin price) plus a fixed fluid milk differential. The vector of shifters for the wholesale frozen products supply

[2]Most federal milk marketing orders utilize three product classes with Class I being fluid products, Class II being soft dairy products, and Class III being hard dairy products. A two class system is used in this study, with all fluid products considered Class I and all manufactured products considered Class II. Hence, the term "Class II price" in this paper refers to the price paid for milk used in manufactured dairy products and is the same as the Minnesota-Wisconsin (M-W) price. This assumption is not much of a departure from reality since the Class II and Class III prices only differ by a marginal amount.

function includes the Class II price which is the most important variable cost to dairy processors.

The dairy price support program directly affects the wholesale cheese and butter markets, where the Commodity Credit Corporation (CCC) provides an alternative source of demand at announced purchase prices. As a result, the butter and cheese wholesale market equilibrium conditions are different than those for the fluid milk and frozen wholesale markets. The wholesale cheese and butter markets have the following general specification for the case where the market is competitive:

(2.1) $Q^{wd} = f(P^{w}|S^{wd})$,

(2.2) $Q^{ws} = f(P^{w}|S^{ws})$,

(2.3) $Q^{ws} = Q^{wd} + \Delta INV + QSP$,

where: Q^{wd} and Q^{ws} are wholesale demand and supply, respectively, P^{w} is the wholesale own price, S^{ws} is a vector of wholesale supply shifters including the Class II milk price, Δ INV is change in commercial inventories, and QSP is quantity of product sold by specialty plants to the government. The variables ΔINV and QSP represent a small proportion of total milk production and are assumed to be exogenous in this model.[3]

As was previously mentioned, the dairy price support program is incorporated by constraining the wholesale market cheese and butter prices to be greater-than-or-equal-to their respective government purchase prices, i.e.:

(3.1) $P^{wc} \geq P^{gc}$,

(3.2) $P^{wb} \geq P^{gb}$,

[3] There are cheese and butter plants that sell products only to the government regardless of the relationship between the wholesale market price and the purchase price. These are general balancing plants that remove excess milk from the market when supply is greater than demand and process the milk into cheese and butter, which is then sold to the government. Because of this, the quantity of milk purchased by the government is disaggregated into purchases from these specialized plants and other purchases. In a competitive regime, the "other purchases" are expected to be zero, while the purchases from specialty plants may be positive. The QSP_c and QSP_b variables are determined by computing the average amount of government purchases of cheese and butter during competitive periods, i.e., when the wholesale price is greater than the purchase price for these two products.

where: P^{gc} and P^{gb} are the government purchase prices for cheese and butter, respectively. In the two policy scenarios where there is a dairy price support program, four regimes are possible: (1) $P^{wc} > P^{gc}$ and $P^{wb} > P^{gb}$; (2) $P^{wc} > P^{gc}$ and $P^{wb} = P^{gb}$; (3) $P^{wc} = P^{gc}$ and $P^{wb} > P^{gb}$; or (4) $P^{wc} = P^{gc}$ and $P^{wb} = P^{gb}$. In the cheese and butter markets, specific versions of equilibrium condition (2.3) apply to the first regime, which is the competitive case. In the second case where the cheese market is competitive, but the butter market is not, the wholesale butter price is set equal to the government purchase price for butter and the equilibrium condition is changed to:

(2.3b) $Q^{wbs} = Q^{wbd} + \Delta INV_b + QSP_b + Q^{gb}$,

where: Q^{gb} is government purchases of butter which becomes the new endogenous variable, replacing the wholesale butter price. For the third case where the butter market is competitive, but the cheese market is not, the wholesale cheese price is set equal to the government purchase price for cheese and the equilibrium condition is changed to:

(2.3c) $Q^{wcs} = Q^{wcd} + \Delta INV_c + QSP_c + Q^{gc}$,

where: Q^{gc} is government purchases of cheese which becomes the new endogenous variable, replacing the wholesale cheese price. Finally, for the last case where both the cheese and the butter markets are not competitive, the wholesale cheese and butter prices are set equal to their respective government purchase prices and the equilibrium conditions are changed to (2.3b) and (2.3c).

The farm milk market is defined by a milk supply function, i.e.:

(4) $Q^{fms} = f(E(P^{fm})|S^{fms})$

where: Q^{fms} is farm raw milk supply, $E[P^{fm}]$ is the expected farm milk price, and S^{fms} is a vector of milk supply shifters. Similar to LaFrance and de Gorter, it is assumed that farmers have perfect information on the milk price at the time production decisions are made, i.e., $E[P^{fm}] = P^{fm}$. To deal with simultaneity between price and quantity, two stage least squares is used in the estimation.

Under the federal milk marketing order program, milk handlers pay Class I and II prices, but farmers receive an average of these prices. That is, the farm milk price is a weighted average of the Class prices for milk, with the weights equal to the utilization of milk among products:

$$(5.4)\qquad P^{fm} = \frac{(P^{II} + d) * Q^{wfs} + P^{II} * Q^{wfzs} + P^{II} * Q^{wcs} + P^{II} * Q^{wbs}}{Q^{wfs} + Q^{wfzs} + Q^{wcs} + Q^{wbs}}$$

where: P^{II} is the Class II price, d is the Class I fixed fluid milk differential (therefore the Class I price is equal to P^{II} + d), Q^{wfs} is wholesale fluid milk supply, Q^{wfs} is wholesale frozen product supply, Q^{wcs} is wholesale cheese supply, and Q^{wbs} is wholesale butter supply.

Finally, the model is closed by the following equilibrium condition:

$$(5.5)\qquad Q^{fms} = Q^{wfs} + Q^{wfzs} + Q^{wcs} + Q^{wbs} + FUSE + OTHER,$$

where FUSE is on-farm use of milk and OTHER is milk used in dairy products other than fluid milk, frozen products, butter, and cheese. Both of these variables represent a small share of total milk production and are treated as exogenous. There are 13 endogenous variables, which in the case of a competitive market regime are: Q^{wf}, Q^{wfz}, Q^{wcd}, Q^{wcs}, Q^{wbd}, Q^{wbs}, P^{wf}, P^{wfz}, P^{wc}, P^{wb}, P^{II}, Q^{fms}, and P^{fm}; and there are 13 equations and identities (see Table 2 for variable definitions).

Estimated Model

The wholesale and farm equations (1.1)-(4) are estimated simultaneously using two stage least squares. The wholesale equations are estimated using quarterly data from 1975 though 1990 while the farm milk supply equation uses quarterly data from 1970 through 1990. The wholesale equations have a shorter time series because some of the demand shifters (generic advertising expenditures) are not available prior to 1975. The data and data sources are listed in the appendix of Kaiser and Forker. To deal with simultaneity bias between price and quantity, instrumental variables are constructed for all prices (wholesale fluid milk, frozen product, cheese, and butter prices, Class II and average milk price) by regressing them on all exogenous variables in the wholesale and farm markets. All equations in the model are specified in double-logarithm functional form. Estimation results for the structural equations are presented in Table 1 with t-values given in parentheses under each coefficient, and all variables are defined in Table 2. R^2 is the adjusted coefficient of determination, DW is the Durbin-Watson statistic, and D-h is the Durbin-h statistic.

Wholesale per capita fluid milk demand (Q^{wfd}/POP) is estimated as a function of the ratio of the wholesale fluid milk price (P^{wf}) to the CPI for nonalcoholic beverage (P^{bev}); per capita income (INCOME) deflated by the CPI for all goods; generic fluid milk advertising expenditures deflated by the media price index (DGFAD); a time trend (T); and seasonal harmonic variables (SIN_1 and COS_1). The CPI for nonalcoholic beverages is used as a proxy for the price of fluid milk substitutes. Generic fluid milk advertising is included to capture the impacts of advertising on fluid milk demand. Similar to Liu et al. and Kaiser et al., a second-order polynomial distributed lag over four quarters with both end point restrictions imposed is specified for generic fluid milk advertising. The variables SIN_1 and COS_1, which represent the ith wave of the sine and cosine, respectively (Doran and Quilkey), are included to capture seasonality in fluid milk demand.

Wholesale per capita frozen product demand (Q^{wfzd}/POP) is estimated as a function of ratio of the wholesale frozen product price (P^{wfz}) to per capita income; a time trend; and seasonal harmonic variables (SIN_1, COS_1, and COS_2). Unlike the demand function for the three other dairy products, the price of frozen product substitutes produced inferior statistical results and therefore is omitted. The specification of the price to income ratio, however, is consistent with the zero homogeneity assumption for price and income (Phlips). Since there was very little generic advertising on frozen products from 1975 through 1990, this variable is not included in the frozen product demand equation. To correct for first-order autocorrelation, a first-order autoregressive error structure is imposed.

Wholesale per capita cheese demand (Q^{wcd}/POP) is estimated as a function of the ratio of the wholesale cheese price (P^{wc}) to the CPI for meat (P^{mea}); per capita income deflated by

Table 1. Results for the Econometric Dairy Model.

Wholesale Fluid Milk Demand:

$$\ln (Q^{wfd}/POP) = -\underset{(20.0)}{2.372} - \underset{(-2.6)}{.043} \ln (P^{wf}/P^{bev}) + \underset{(6.7)}{.254} \ln (INCOME/CPI) + \underset{(8.2)}{.005} \ln DGFAD$$

$$+ \underset{(8.2)}{.008} \ln DGFAD_{-1} + \underset{(8.2)}{.009} \ln DGFAD_{-2} + \underset{(8.2)}{.008} \ln DGFAD_{-3} + \underset{(8.2)}{.005} \ln DGFAD_{-4} - \underset{(-13.6)}{.068} \ln T$$

$$+\underset{(10.8)}{.021} SIN_1 + \underset{(16.2)}{.031} COS_1 + \mu^{wfd} \qquad R^2 = .94;\ DW = 1.5$$

Wholesale Frozen Product Demand:

$$\ln (Q^{wfzd}/POP) = -\underset{(43.7)}{4.783} - \underset{(-4.10)}{.178} \ln (P^{wfz}/INCOME) - \underset{(-3.2)}{.034} \ln T - \underset{(-31.6)}{.147} SIN_1 - \underset{(-34.3)}{.157} COS_1$$

$$- \underset{(-8.2)}{.023} COS_2 + (1/(1 - \underset{(1.5)}{.198} L))\ \mu^{wfzd} \qquad R^2 = .97;\ DW = 1.9$$

Wholesale Cheese Demand:

$$\ln (Q^{wcd}/POP) = -\underset{(-4.4)}{3.365} - \underset{(-1.3)}{.107} \ln (P^{wc}/P^{mea}) + \underset{(1.7)}{.308} \ln (INCOME/CPI) + \underset{(5.5)}{.078} \ln T$$

$$-\underset{(-2.3)}{.041} DTP + \underset{(6.3)}{.260} DUM_{82.2} - \underset{(-10.0)}{.412} DUM_{83.1} + \underset{(6.0)}{.031} COS_2 + \underset{(3.8)}{.461} U_{-1}^{wcd} \qquad R^2 = .88;\ DW = 2.0$$

Wholesale Butter Demand:

$$\ln (Q^{wbd}/POP) = -\underset{(-2.6)}{3.138} - \underset{(-1.6)}{.166} \ln (P^{wb}/P^{fat}) + \underset{(1.1)}{.606} \ln (INCOME/CPI) + \underset{(2.2)}{.003} \ln DGBAD$$

$$- \underset{(-1.8)}{.00007} T^2 - \underset{(-1.5)}{.062} MDP - \underset{(-2.8)}{.267} DUM_{77.2} - \underset{(-3.6)}{.351} DUM_{80.2} - \underset{(-4.4)}{.294} DM_{89.12} + \underset{(4.7)}{.079} COS_1$$

$$+ \underset{(2.9)}{.033} COS_2 + \mu^{wbd} \qquad R^2 = .61;\ DW = 2.1$$

Wholesale Fluid Milk Supply:

$$\ln Q^{wfs} = \underset{(3.7)}{.301} + \underset{(6.9)}{.138} \ln (P^{wf}/(P^{II}+d)) - \underset{(-3.0)}{.015} \ln (P^{fe}/(P^{II}+d)) + \underset{(7.5)}{.637} \ln (Q^{wfs})_{-1}$$

$$+ \underset{(1.8)}{.150} \ln (Q^{wfs})_{-4} + \underset{(9.1)}{.041} COS_1 + \underset{(2.5)}{.004} COS_2 + (1/(1 + \underset{(1.8)}{.250} L))\ \mu^{wfs} \qquad R^{\beta} = .96;\ D\text{-}h = -.4$$

Table 1. (Continued).

Wholesale Frozen Product Supply:

$$\ln Q^{wfzs} = \underset{(5.8)}{.496} + \underset{(1.0)}{.067} \ln (P^{wfz}/P^{II}) + \underset{(2.1)}{.261} \ln (Q^{wfzs})_{-4} + \underset{(6.2)}{.058} \ln T - \underset{(-2.6)}{.109} SIN_1$$

$$- \underset{(-6.0)}{.117} COS_1 - \underset{(-3.6)}{.016} COS_2 + \underset{(3.0)}{.379} \mu_{-1}^{wfzs} \qquad R^2 = .97;\ D\text{-}h = 1.4$$

Wholesale Cheese Supply:

$$\ln Q^{wcs} = \underset{(1.5)}{.882} + \underset{(1.3)}{.360} \ln (P^{wc}/P^{II}) + \underset{(4.1)}{.442} \ln (Q^{wcs})_{-1} + \underset{(5.5)}{.531} \ln (Q^{wcs})_{-4} - \underset{(-3.5)}{.069} MDP$$

$$- \underset{(-1.6)}{.032} DTP + \underset{(3.6)}{.032} SIN_1 - \underset{(-3.4)}{.024} COS_1 + \underset{(4.0)}{.020} COS_2 + (1/(1 - \underset{(3.8)}{.530} L))\ \mu^{wcs} \qquad R^2 = .96;\ D\text{-}h = .6$$

Wholesale Butter Supply:

$$\ln Q^{wbs} = \underset{(3.4)}{1.277} + \underset{(1.9)}{.230} \ln (P^{wb}/P^{II}) + \underset{(1.4)}{.498} \ln (Q^{wbs})_{-1} + \underset{(3.6)}{.004} T - \underset{(-1.6)}{.055} MDP$$

$$- \underset{(-2.1)}{.079} DTP + \underset{(15.3)}{.222} SIN_1 + \underset{(1.4)}{.037} COS_1 + \mu^{wbs} \qquad R^2 = .87;\ D\text{-}h = .3$$

Farm Milk Supply:

$$\ln Q^{fms} = \underset{(6.5)}{1.793} + \underset{(3.3)}{.113} \ln (P^{fm}/P^{feed}) - \underset{(-.4)}{.007} \ln (P^{cow}/P^{fr}) + \underset{(1.9)}{.096} \ln Q^{fms}_{-1}$$

$$+ \underset{(5.4)}{.452} \ln Q^{fms}_{-4} + \underset{(6.2)}{.002} FARMT - \underset{(-2.3)}{.023} MDP - \underset{(-4.0)}{.042} DTP - \underset{(-6.1)}{.035} COS_1 + \underset{(3.5)}{.412} \mu^{fms}$$

$$R^2 = .95;\ D\text{-}h = 2.0$$

Table 2. Variable Definitions for the Econometric Model.

Endogenous Variables (in alphabetical order):

P^{fm} = farm milk price measured in \$/cwt.,
P^{II} = Class II price for raw milk measured in \$/cwt.,
P^{wb} = wholesale price for butter measured in cents/lb.,
P^{wc} = wholesale price for cheese measured in cents/lb.,
P^{wf} = wholesale fluid milk price index (1982 = 100),
P^{wfz} = wholesale price index for frozen dairy products (1982 = 100),
Q^{fms} = raw milk supply measured in bil. lbs.,
Q^{wbd} = wholesale butter demand measured in bil. lbs. of milkfat equivalent,
Q^{wbs} = wholesale butter supply measured in bil. lbs. of milkfat equivalent, ($Q^{wbs} = Q^{wbd}$),
Q^{wcd} = wholesale cheese demand measured in bil. lbs. of milkfat equivalent,
Q^{wcs} = wholesale cheese supply measured in bil. lbs. of milkfat equivalent, ($Q^{wcs} = Q^{wcd}$),
Q^{wfd} = wholesale fluid milk demand measured in bil. lbs. of milkfat equivalent,
Q^{wfs} = wholesale fluid milk supply measured in bil. lbs. of milkfat equivalent, ($Q^{wfs} = Q^{wfd}$),
Q^{wfzd} = wholesale frozen dairy product demand measured in bil. lbs. of milkfat equivalent,
Q^{wfzs} = wholesale frozen dairy product supply measured in bil. lbs. of milkfat equivalent, ($Q^{wfzs} = Q^{wfzd}$),

Exogenous Variables and Other Definitions (in alphabetical order):

COS_1 = harmonic seasonal variable representing the first wave of the cosine function,
COS_2 = harmonic seasonal variable representing the second wave of the cosine function,
CPI = Consumer price index for all items (1982-84 = 100),
d = Class I fixed price differential for raw milk measured in \$/cwt.,
DGBAD = generic butter advertising expenditures deflated by the media price index, measured in thousand \$,
DGFAD = generic fluid milk advertising expenditures deflated by the media price index, measured in thousand \$,
D-h = Durbin-h statistic,
$DM_{89.12}$ = intercept dummy variable equal to 1 for 1989.1 and 1989.2, equal to 0 otherwise,

Table 2. (Continued).

DTP = intercept dummy variable for the Dairy Termination Program equal to 1 for 1986.2 through 1987.3; equal to 0 otherwise,

$DUM_{77.2}$ = intercept dummy variable equal to 1 for 1977.2, equal to 0 otherwise,

$DUM_{80.2}$ = intercept dummy variable equal to 1 for 1980.2, equal to 0 otherwise,

$DUM_{82.2}$ = intercept dummy variable equal to 1 for 1982.2, equal to 0 otherwise,

$DUM_{83.1}$ = intercept dummy variable equal to 1 for 1983.1, equal to 0 otherwise,

DW = Durbin-Watson statistic,

FARMT = time trend variable for the farm-level equations, equal to 1 for 1970.1,...,

INCOME = disposable personal income per capita, measured in thousand $,

L = lag operator,

MDP = intercept dummy variable for the Milk Diversion Program equal to 1 for 1984.1 through 1985.2; equal to 0 otherwise,

P^{bev} = Consumer retail price index for nonalcoholic beverages (1982-84 = 100),

P^{cow} = U.S. average slaughter cow price measured in $/cwt.,

P^{fat} = Consumer retail price index for fats and oils (1982-84 = 100),

P^{fe} = Producer price index for fuel and energy (1967 = 100),

P^{feed} = U.S. average price per ton of 16% protein dairy feed,

P^{fr} = U.S. index of prices received by farmers;

P^{mea} = Consumer retail price index for meat (1982-84 = 100),

POP = U.S. population measured in millions,

R^2 = adjusted coefficient of determination,

SIN_1 = harmonic seasonal variable representing the first wave of the sine function,

T = time trend variable for the retail and wholesale-level equations, equal to 1 for 1975.1,...,

μ^{fms} = error term for the farm milk supply equation,

μ^{wbd} = error term for the wholesale butter demand equation,

μ^{wbs} = error term for the wholesale butter supply equation,

μ^{wcd} = error term for the wholesale cheese demand equation,

μ^{wcs} = error term for the wholesale cheese supply equation,

μ^{wfd} = error term for the wholesale fluid demand equation,

μ^{wfs} = error term for the wholesale fluid supply equation,

μ^{wfzd} = error term for the wholesale frozen product demand equation,

μ^{wfzs} = error term for the wholesale frozen product supply equation, the CPI for all goods; a time trend; an intercept dummy variable for the quarters that the 1986-87 Dairy Termination Program (DTP) was in effect; two intercept dummy variables for outliers for quarter 2 of 1982 ($DUM_{82.2}$) and quarter 3 of 1983 ($DUM_{83.1}$); and one seasonal harmonic variable (COS_2). The CPI for meat is included as a proxy for the price of cheese substitutes. The dummy variable for the DTP is included because this program substantially reduced cow numbers via a government buyout of dairy animals and hence milk available for cheese when the program was in effect. Generic cheese advertising is not included in this equation because it is not statistically significant. Based on the autocorrelation and partial autocorrelation functions, a first-order moving average error structure is specified.

Wholesale per capita butter demand (Q^{wbd}/POP) is estimated as a function of the ratio of the wholesale butter price (P^{wb}) to the CPI for fats and oils (P^{fat}); per capita income deflated by the CPI for all items; generic butter advertising deflated by the media price index (DGBAD); a time trend; an intercept dummy variable for the quarters that the 1984-85 Milk Diversion Program was in effect (MDP); three intercept dummy variables corresponding to outliers in quarter 2 of 1977 ($DUM_{77.2}$), quarter 2 of 1980 ($DUM_{80.2}$), and quarters 1 and 2 of 1989 ($DM_{89.12}$); and seasonal harmonic variables (COS_1 and COS_2). The CPI for fats and oils is included as a proxy for the price of butter substitutes. The specification of current generic butter advertising yields better statistical results than the second-degree polynomial distributed lag specification and is therefore used in the butter demand equation. It appears that consumers respond immediately to generic butter advertising and the impact of such advertising is short-lived. The intercept dummy variable for the MDP captures the reduction in milk availability that this program accomplished while it was in effect.

Wholesale fluid milk supply (Q^{wfs}) is estimated as a function of the ratio of the wholesale fluid milk price to the Class I price ($P^I = P^{II} + d$, where d is the fixed Class I price differential); the ratio of the Producer Price Index (PPI) for fuel and energy (P^{fe}) to the Class II price plus the Class I differential; fluid milk supply lagged one and four quarters; and seasonal harmonic variables (COS_1 and COS_2). The Class I milk price represents the most important variable cost to fluid processors, while the PPI for fuel and energy is used as a proxy for variable energy costs. The specification of lagged endogenous variables represents capacity constraints, while the seasonal harmonic variables capture seasonality in the fluid milk supply. A first-order autoregressive error structure is specified to correct for autocorrelation.

Wholesale frozen product supply (Q^{wfzs}) is estimated as a function of the ratio of the wholesale frozen product price to the Class II price (P^{II}); frozen product supply lagged one and four quarters; a time trend; and seasonal harmonic variables (SIN_1, COS_1, and COS_2). The Class II price is included because it represents the most important variable cost to frozen product manufacturers, while the lagged endogenous variables are incorporated as capacity constraints on frozen product supply. The time trend is a proxy for technological change in frozen product manufacturing, and the seasonal harmonic variables capture seasonality in supply. Based on the autocorrelation and partial autocorrelation functions, a first-order moving average error structure is imposed.

Wholesale cheese supply (Q^{wcs}) is estimated as a function of the ratio of the wholesale cheese price to the Class II price; lagged cheese supply one and four quarters; two intercept dummy variables for the MDP and DTP; and seasonal harmonic variables (SIN_1, COS_1, and COS_2). The Class II price is included since it is the most important variable cost to cheese manufacturers, while the lagged endogenous variables represent capacity constraints in cheese manufacturing. The two intercept dummy variables correspond to the quarters that the 1984-85 MDP and the 1986-87 DTP were in effect and captures their respective impacts on reducing the milk supply. The harmonic variables measure the seasonality in cheese supply. A first-order autoregressive error structure is specified to correct for autocorrelation.

Wholesale butter supply (Q^{wbs}) is estimated as a function of the ratio of the wholesale butter price to the Class II price; lagged butter supply by one quarter; a time trend; intercept dummy variables for the MDP and DTP; and seasonal harmonic variables (SIN_1 and COS_1). The Class II price is included since it is the most important variable cost to butter manufacturers, while butter supply lagged one quarter is a proxy for capacity constraints in butter manufacturing. The time trend is a proxy for technological change in butter processing, and the intercept dummy variables for the two supply control programs measure the effects they had on reducing milk availability for butter. The harmonic variables capture the seasonality in butter supply.

For the farm milk market, the milk supply equation (Q^{fms}) is estimated as a function of the ratio of the farm milk price (P^{fm}) to the price of 16% protein feed (P^{feed}); the price of slaughter cows (P^{cow}) deflated by the index of prices received by farmers (P^{fr}); milk supply lagged one and four quarters; a time trend (FARMT); two intercept dummy variables for the MDP and DTP; and a seasonal harmonic variable (COS_1). The price of 16% protein feed is included because it is one of the most important variable costs to dairy farmers, while the deflated price of slaughtered cows is a proxy for opportunity costs of milk production. Lagged milk supply is included as biological capacity constraints for current milk production, while the time trend measures technological progress in dairy farming. The two intercept dummy variables capture the reduction in milk supply that occurred during the MDP and DTP, and the harmonic variable measures seasonality in milk production. A moving average error structure is imposed to correct for autocorrelation.

Regarding statistical fit, most of the estimated equations are reasonable with respect to R^2 and the signs on all coefficients are as expected. In all but two equations, the adjusted coefficient of determination is above .87, and all but three are above .94. The two equations that yield the lowest R^2 are the wholesale butter demand and supply equations. The wholesale butter demand equation has the lowest R^2 (.61), and the wholesale butter supply equation has an R^2 of .87. On the whole, the equations are deemed reasonable for the simulation model.

Model Validation

To determine the validity of the dairy model in evaluating the various scenarios, the model is dynamically simulated to assess its ability to replicate historical values for the endogenous variables. The time period chosen for this dynamic in-sample simulation is from the first quarter of 1980 (i.e., 1980.1) through the fourth quarter of 1990 (i.e., 1990.4). This period is also the period used in the simulation and is chosen because it corresponds to a time in which there was a lot of discussion of implementing alternative dairy policies.

The dynamic simulation is conducted as follows. First, all exogenous variables are set equal to their historic levels for the simulation period. Second, all lagged dependent variables are set equal to their actual levels for the previous periods and the system of equations product specific versions of equations [(1.1) through (5.5)] is solved simultaneously using the Newton method. Finally, the predicted endogenous variables become the lagged endogenous variables for the subsequent period of the simulation. This process is repeated until the last period of the simulation (1990.4) is reached.

Table 3 shows the root-mean-square-percent simulation error (RMSPE), as well as the actual and simulated average values for all of the endogenous variables in the model. Generally, the RMSPEs for the supply and demand quantities are quite reasonable. All wholesale and farm supply and demand quantities have RMSPEs under 8.1%. Moreover, most of the quantity variables have RMSPEs under 5%. With respect to prices, the RMSPEs tend to be somewhat higher, ranging from a low of 2.7% for the wholesale butter price to a high of 11.6% for the wholesale cheese price. Finally, the RMSPE for CCC purchases is 87.2%. While this may appear high, it is due to the small magnitude of this variable, i.e., a small deviation from the actual value leads to a large RMSPE. Because the simulation model is to be used for comparing the differences among various dairy policy scenarios rather than for prediction, the model is deemed reasonable for this purpose.

Government Dairy Policy Scenarios

There are five policy scenarios considered here: (1) baseline current program, (2) immediate deregulation through abolishing the dairy price support program, (3) gradual

Table 3. Quarterly Averages for Actual and Simulated Endogenous Variables from the Dynamic Simulation and Root-Mean-Square Percent Errors.

Endogenous Variable	Unit	Actual Average	Simulated Average	Root-Mean Square Percent-Error
Fluid milk demand	bil lbs	13.04	13.05	0.9
Frozen product demand	bil lbs	3.20	3.20	2.5
Cheese demand	bil lbs	8.93	8.91	3.8
Cheese supply	bil lbs	9.72	9.33	5.2
Butter demand	bil lbs	4.69	4.64	7.9
Butter supply	bil lbs	6.38	6.40	8.1
Wholesale fluid milk price	1982=100	104.28	102.82	11.3
Wholesale frozen price	1982=100	106.36	106.57	4.6
Wholesale cheese price	cents/lb	1.33	1.33	11.6
Wholesale butter price	cents/lb	1.38	1.37	2.7
Class II price	$/cwt	11.94	11.82	10.7
Farm milk supply	bil lbs	34.95	34.57	2.2
Farm milk price	$/cwt	13.10	12.77	9.3
CCC total	bil lbs	2.50	2.17	87.2

deregulation by lowering the government purchases prices for cheese and butter by 10% per year, (4) deficiency payment program, and (5) mandatory supply control program. For each scenario, it is assumed that the policy was in effect for the period 1980.1 through 1990.4. Under all five policy scenarios, the federal milk marketing order system of classified pricing is maintained. The following discusses the assumptions for each policy scenario.

In the baseline policy scenario, it is assumed that purchase price adjustments each year are based on the actual mandated levels under legislation from 1980 through 1990. That is, the government purchase prices for cheese and butter are set equal to their actual levels for this period. The baseline represents the historical simulation scenario of actual policy from which the alternative policies should be compared.

The immediate deregulation scenario assumes that the dairy price support program is abolished at the beginning of 1980. In this case, the model is modified by setting the purchase prices for cheese and butter to zero. In essence, this is equivalent to the government ceasing its purchases of storable dairy products under the price support program.

Because it is unlikely that the government would abolished the dairy price support program immediately, a second deregulation scenario is included which phases out the program more gradually. Under this scenario, it is assumed that the government continues to purchase cheese and butter from willing sellers, but the purchase prices for both products are reduced by 10% each year after 1980. This gradual deregulation is not as disruptive to the wholesale and farm markets, and would likely be more politically acceptable than the immediate abolishment of the price support program.

The deficiency payment program scenario assumes that the dairy price support program is abolished and replaced by a $13.00 per hundredweight target price for the farm milk price. The model is modified by adding the following requirement: if the simulated farm milk price for any quarter is below $13.00 per hundredweight, then a deficiency payment is added to the milk price to make the effective price $13.00 and the model is resolved for that quarter. On the other hand, if the farm milk price for any quarter is at or above $13.00 per hundredweight, then no deficiency payment is made.

In the supply control scenario, it is assumed that the dairy price support program is eliminated and the government instead directly supports the farm milk price at $13.00 per hundredweight by restricting the milk supply. It is assumed that the government's ability to control supply is perfect, which is a reasonable assumption since the government could simply not pay farmers for over-quota milk sales. The model is modified by adding the following requirement: if the simulated farm milk price for any quarter is less than $13.00 per hundredweight, then 50 million pounds of milk is subtracted from the milk supply and the model is resolved given the new milk supply level. This iterative procedure of reducing the milk supply in 50 million pound increments is continued until the farm milk price is $13.00 or more.

Results

The equilibrium quantities and prices for each of the five scenarios are simulated over the time period 1980.1 through 1990.4. The results of the five policy scenario are given in Table 4, which reports the baseline results and the percentage change in the quarterly average quantities and prices from the baseline scenario.

Not surprisingly, the milk supply is the lowest in the supply control scenario (3.7% lower than the baseline) and highest in the deficiency payment program scenario (1.1% higher than baseline), as indicated in Table 4. The reason milk supply is highest in the deficiency payment scenario is due to the farm price being the highest in this case compared with all other policies that do not restrict supply. The milk supply under the two deregulation scenarios is quite comparable. In the case of immediate deregulation, the milk supply is about 2.7% lower, on average, than the baseline, while the milk supply under gradual deregulation is about 2% lower than the baseline. Under all five policies, milk supply is increasing over the period 1980-90, which is primarily due to improved technology.

The farm milk price is highest under the supply control policy, averaging almost 6% higher than the price in the baseline (Table 4). On the other hand, the farm price is the lowest in the immediate deregulation scenario, where it is about 7% lower than the baseline. It is interesting to note, however, that in the case of immediate deregulation, the farm price is much lower than the baseline price at the beginning of the simulation, but is closer to the baseline towards the end of the simulation after most adjustments to deregulation have been made. The farm milk price in the gradual deregulation scenario is 5.4% lower than the baseline, while the farm price under the deficiency payment policy is 1.8% higher than the baseline, on average. In addition to having the lowest farm milk price, the immediate deregulation policy also produces the most price volatility, having a coefficient of variation for the farm price of 13.3%. The deficiency payment program is at the other extreme in terms of farm price variability with a coefficient of variation of .1%. The baseline, gradual deregulation, and supply control policies

Table 4. Endogenous Variables Under the Five Dairy Policy Scenarios as a Percent of their Respective Baseline Values.

Endogenous Variable	Unit	Baseline (quarterly average)	Immediate Deregulation (% change)	Gradual Deregulation (% change)	Target Price Deficiency Payment (% change)	Supply Control (% change)
Fluid milk demand	bil lbs	13.05	0.25	0.19	0.74	-0.18
Frozen product demand	bil lbs	3.20	0.62	0.47	1.87	-0.45
Cheese demand	bil lbs	8.91	0.85	0.64	2.62	-0.69
Cheese supply	bil lbs	9.33	-0.96	-1.08	0.73	-2.43
Butter demand	bil lbs	4.64	6.96	5.04	9.25	5.05
Butter supply	bil lbs	6.40	-14.21	-10.09	-12.55	-15.60
Wholesale fluid milk price	1982=100	102.82	-5.47	-4.27	-15.64	4.13
Wholesale frozen price	1982=100	106.57	-3.65	-2.86	-10.65	2.76
Wholesale cheese price	cents/lb	1.33	-6.95	-5.31	-21.28	6.38
Wholesale butter price	cents/lb	1.37	-28.58	-22.15	-37.25	-21.18
Class II price	$/cwt	11.82	-7.80	-6.06	-22.06	6.01
Farm milk supply	bil lbs	34.57	-2.74	-2.04	1.09	-3.65
Farm milk price	$/cwt	12.77	-6.97	-5.42	1.83	5.86
CCC total[1]	bil lbs	2.25	NA	-47.77	NA	NA
Producer surplus	bil $	3.97	-9.37	-7.32	3.21	3.84
Government cost[2]	bil $	0.28	NA	-64.29	1,478.57	NA
Deficiency payment[3]	$/cwt				2.82	

[1]In the immediate deregulation, deficiency payment, and supply control scenarios, there are no CCC purchases.

[2]Government costs for the baseline and gradual deregulation scenarios are calculated as the product of the purchase price for cheese times total CCC purchases. Government costs of the deficiency payment program are calculated as the product of the deficiency payment times milk supply. There are no government costs for the immediate deregulation and supply control scenarios.

[3]The number for the deficiency payment is the actual average payment on a $/cwt. basis rather than a percentage change basis.

have coefficient of variations for the farm price of 8.5%, 11.7%, and 5.4%, respectively.

Regarding farm welfare, producers are best off in the supply control scenario, where producer surplus is 3.8% higher, on average, than the baseline (Table 4). The deficiency payment program is close behind the supply control program in this regard, with producer surplus being 3.2% higher, on average, than the baseline. Dairy farmers are worse off, as a group, under both deregulation scenarios. Under immediate deregulation, producer surplus is 9.4% lower than the baseline, while gradual deregulation results in producer surplus being 7.3% lower than the baseline. For all five policies, there is a general upward trend in producer surplus over time, which is due to a positive trend in milk supply. These results suggest that producers, as a group, would favor supply control and the deficiency payment program over the current price support program, but would not favor deregulation.

The cost of each program is another important dimension of any policy analysis. Government costs for the baseline and the gradual deregulation scenarios are calculated as the product of the purchase price for cheese (converted to a dollars per hundredweight of raw milk basis) times total CCC purchases on a milkfat equivalent basis.[4] Government costs for the deficiency payment program are computed as the product of the deficiency payment (dollars per hundredweight) times the farm milk supply. There are no government costs for the immediate deregulation, or the supply control scenarios.

The simulation indicates that the deficiency payment program is by far the most expensive for the government (Table 4). Government costs for this program average $4.4 billion per quarter, which is 1,478% higher than the $.28 billion per quarter that the baseline policy costs. This policy, therefore, would obviously be politically unacceptable especially considering current federal budget deficit pressures. This does not mean that any deficiency

[4] The purchase price for butter is not used here because butter is a jointly produced product with nonfat dry milk, and one needs the nonfat dry milk purchase price to convert these two products to a milk equivalent basis. Since nonfat dry milk is not included in the model, one can not compute the milk equivalent purchase price for butter and nonfat dry milk. The use of the cheese purchase price only to measure monetary costs to the CCC is reasonable since the purchase prices are quite close when converted to a milk equivalent measure.

payment program would be politically unacceptable because one could cut the costs by lowering the target price of $13.00, and/or requiring some sort of supply control by farmers to receive the benefits of the program. Gradual deregulation would save the tax payers money relative to the baseline.

Purchases of dairy products by the CCC under the gradual deregulation scenario are 47.8% lower than they are under the baseline. Government costs in this case are 64.3% lower, on average, than the baseline because purchase prices are also lower than the baseline. Consequently, if the government would have started to decrease the purchases prices in 1981 by 10% per year, government purchases and costs of the dairy price support program would not have skyrocketed like they actually did. The best policies in terms of reducing government costs are the immediate deregulation and supply control policies, which have no government costs associated with them. Given the current government cost cutting atmosphere in Washington, the supply control and deregulation policy options might attract some interest.

Regarding the wholesale market, commercial demand is the highest under the deficiency payment program, where wholesale demand for all products (fluid milk, frozen products, cheese, and butter) is 2.8% higher than what it is in the baseline. This is due to the fact that average wholesale prices for all four products are the lowest in this scenario (see Table 4). Commercial wholesale demand is also higher under the two deregulation scenarios compared to the baseline. Wholesale demand for all products is 1.5% and 1.1% higher for the immediate deregulation and gradual deregulation policies, respectively, than the baseline. This is due to the wholesale prices for all products being lower under deregulation relative to the baseline. While fluid milk, frozen product, and cheese demand is lower in the supply control scenario than the baseline, butter demand is actually 5.1% higher. This seemly un-intuitive result is explained by looking at the wholesale butter price, which is 21.2% lower than the baseline. The reason for the lower butter price is because there is no support program. This result suggests that the market value for butter is substantially lower than what was reflected by the butter purchase price from 1980-90. It is interesting that this does not happen to the wholesale cheese price, which is 6.4% higher than the baseline.

Extrapolating the wholesale results to the retail level, it appears that consumers would favor the deficiency payment program over all other policies because it leads to the lowest prices. Under the deficiency payment program, the wholesale fluid milk price is 2.9 times lower, the wholesale frozen product price is 2.9 times lower, the wholesale cheese price is 3.1 times lower, and the wholesale butter price is 1.3 times lower than the policy with the next lowest price. However, this tremendous magnitude of price advantage to consumers of the deficiency payment program would likely be offset by the large tax burden required to pay for the program. Since consumers are also taxpayers, they would obviously find this an unattractive aspect of the deficiency payment program. Consumers are better off under the two deregulation scenarios than the baseline. Regarding immediate deregulation, wholesale fluid milk, frozen product, cheese, and butter prices are 5.5%, 3.7%, 7%, and 28.6% lower than what they are in the baseline. All wholesale prices for gradual deregulation are also lower than the baseline, but slightly higher than the immediate deregulation case (see Table 4). Wholesale fluid milk, frozen product, and cheese prices are higher in the supply control scenario than the baseline. The wholesale butter price, however, is lower under supply control than the baseline.

Summary

The purpose of this paper was to examine the potential market impacts of five different dairy policy scenarios. The five policies were: (1) a baseline price support program scenario, (2) a deregulation scenario where the price support program is eliminated, (3) a deregulation scenario where the support prices for dairy products are decreased by 10% per year, (4) a target price-deficiency payment program scenario, and (5) a mandatory supply control program scenario. A model of the national dairy industry was used to simulate quarterly equilibrium price and quantity values at the farm and wholesale levels for each policy over the period 1980-

90.

The results indicated that there are gainers and losers for each policy option. Consumers are better off under the deficiency payment program and both deregulation scenarios because prices are lower, which enables them to consume more dairy products. On the other hand, consumer are worse off under supply control where, with the exception of butter, wholesale prices are at their highest. Farmers, as a group, are better off under the supply control and deficiency programs. Farm milk prices and producer surplus are highest under these two policies. Producers suffer the most in the immediate deregulation scenario where both the farm price and producer surplus are at their lowest levels. Tax payers are best off under immediate deregulation and supply control, while substantially worse off under the deficiency payment program. These results suggest that the relative political weight that politicians give to consumers, farmers, and tax payers will be quite important in shaping future dairy policy legislation.

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