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Policy Change and the Dairy Cooperatives Sector, 1980-1988: An Examination of Operational Performance*

by

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Abstract

This paper employs the dual approach to trace the impact of public policy instruments upon the operational and financial performance of U.S. dairy cooperatives. A restricted profit function is applied to the Operations and Finance Statements for years 1980-1988 of thirty major dairy cooperatives. The data set for this study is provided by the Agricultural Cooperatives Service, USDA. A specification search such as described in Mountain and Hsaio (1989) is conducted to ensure the most appropriate fit for the data provided.

From the estimated parameters, output supply and factor demand elasticities will be obtained by way of well-known functional relationships. From these elasticities, the short-run effect of any change in Federal Marketing Order prices upon cooperative revenues may be calculated in a straightforward manner. By retracing the price effects of Federal Order policy changes in a stepwise manner, the impact on cooperative operations and revenues of these changes is approximated.

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Introduction and Problem Statement

Farm policy program analysis typically concentrates on the impact on farmers and consumers. This is justifiably so because farmers and consumers are the ultimate recipients of program's effects. However, because of the importance of farmer cooperatives in the marketing of farm products, a complete analysis of program effects on farmers should include an evaluation of program impact on the operational performance of farmer cooperatives.

A farmer cooperative is a business extension of its members' farm-firms. The farmer-members are the owners and users of the cooperative and rely on it to market their products and/or to supply inputs. Members share in the net earnings or losses of the cooperative. The cooperative's financial condition and operating results have an important bearing on the members' well-being. Thus, an important question regarding farm programs is whether or not the intended direct effects on farmers are complemented or reduced by program impacts on farmers' cooperatives. If farm policies have negative effects on farm cooperatives, then policy effectiveness for improving the welfare of farmers is reduced.

An example of the conflicting impacts of a farm program is the Payment-in-Kind (PIK) for crops in 1982-83. While the program substantially increased farm income, it also reduced the volume of commodities and supplies handled by cooperatives and weakened the financial performance of cooperatives in the process. Many cooperatives, expecting low sales volumes, high per unit operating costs, and low (if not negative) net margins, took belt-tightening measures such as curtailing of member services that had been previously provided at low or no charge. Consequently, the well-being of the farmer owners of the cooperatives was reduced as a result of the cooperatives' weakened financial position and reduced services (Ling).

Dairy Policy Changes Since 1980

Federal dairy price policies and associated programs have undergone several important changes during the 1980s (see Table 1). In 1981, reductions in the level of farm price support was begun with the elimination of a previously mandated price support increase. The Budget Reconciliation Act of 1983 eliminated another previously legislated price support increase and provided for assessments of $.50 per cwt. on producers' milk sales to help defray costs of the price support program. The Dairy and Tobacco Stabilization Act of 1984 provided for a mandatory promotion assessment of $.15 per cwt. assessment on all producer milk sales, continuation of producer assessments to defray price support costs and a voluntary paid diversion program that paid producers $10.00 per cwt. for reduction in milk sales of 5 to 30 percent from base year production for the period January 1, 1984 through March 31, 1985. The Food Security Act of 1985 mandated annual price support reductions of $.50 per cwt. when projected annual CCC milk purchases exceed 5 billion lbs. of milk equivalent, a whole herd buy-out program that paid producers to exit from dairying for five years (resulting in payments to producers for 12 billion lbs. of reduced milk production), and increases in Class I prices in Federal Marketing Order markets that ranged up to $2.00 per cwt. All of these program changes have had direct impact on milk producers, some enhancing welfare, some reducing it.

Recent legislation before Congress suggested the establishment of multiple basing points as part of a Federal Order Milk Marketing system. Since a basing point is a location with a minimum Class I price differential and from which transportation-linked Class I differentials in other regions are calculated, a multiple basing point proposal then would establish various basing points about the United States in addition to the single existing point in Eau Claire, Wisconsin. Other proposed (and often contradictory) policy changes include: the establishment of a single national milk marketing order in contrast to the 43 orders under the current system, the elimination of the Class I differentials (the price premiums provided for in the order system for Grade A milk in fluid use), and the removal of economic barriers to reconstituting dairy products for fluid use. (Reconstitution is the removal of water from milk to facilitate shipping and storing and the replacement of the water when and where the milk is used.)

Table 1

Dairy Policy Action, 1980 - 1988

1980	Support price frozen at $13.10 cwt.
1981-83	**Omnibus Budget Reconciliation Act of 1982** $.50/cwt deducted from all milk marketed as of April 1983 $.50/cwt additional deducted as of Sept. 1 but refundable to producers who reduce marketings by a specified amount
1984-85	**Dairy and Tobacco Adjustment Act of 1983** support price lowered to $12.60 as of Dec. 1, 1983 $.50/cwt deduction continued through March 1985 **Dairy Diversion Program**, Jan. 1984 - March 1985 producers paid $10/cwt for reductions from their base milk marketings support price reduced .50/cwt on April 1 support price reduced .50/cwt on July 1
1986-88	**Food Security Act of 1985** support price lowered to $11.60/cwt for calendar year 1986 support price lowered to $11.35 for Jan. - Sept. 1987 support price must be adjusted by .50/cwt on Jan. 1, 1988, 1989, and 1990 when projected removals exceed 5 billion lbs. or are less than 2.5 billion lbs. -- deductions authorized and amount -- Apr. - Dec. 1986 .50/cwt Apr. - Sept. 1986 .12/cwt Jan. - Sept. 1987 .25/cwt Jan. - Dec. 1988 .50/cwt Jan. - Dec. 1988 .025/cwt (additional) **Dairy Termination Program** producers whose bids were accepted agreed to slaughter or export all female dairy cattle and not participate in dairy production or allow their facilities to be used for dairying for at least 5 years (producers who had marketed almost 12 billion lbs. left the industry)

The impact of several of these proposals upon the entire dairy industry has been estimated (Fallert and Buxton; Hallberg, et al.; Fleming and Hamm; McDowell, Fleming and Fallert; Novakovic). To date, no research examines the effects of these policies upon dairy cooperatives in particular. It is against this background that the need for developing cooperative sector models for policy analysis arises. This paper describes the effort to initiate work on this question.

Objectives

To trace the effects of dairy policy changes upon cooperative performance, a normalized profit function is applied to the Operations and Finance Statements (USDA, ACS) from seven prominent U.S. dairy cooperatives. From the estimated parameters, output supply and factor demand elasticities may be obtained by way of well-known functional relationships. Output supply elasticities provide an estimate of cooperative output responsiveness with respect to changes in the output price. Factor demand elasticities describe how input price changes affect the cooperative's demand for those inputs in the production of dairy products. Together, these two measures provide a reasonably complete description of producer response to output and factor price changes.

Estimates of the impact of historical dairy policy changes were computed and obtained from various sources (Boynton and Novaknovic; Halverson, et al.; Miller; Miller and Short). These price changes will be used, together with the estimated output supply and factor demand elasticities, to quantify the impact of policy changes from 1980-1988 upon the dairy cooperatives sector.

Methodology

Dairy Cooperative Response to Market Changes: A Duality Approach

Among other benefits to economic analysis, production theory based on the duality relationship between production functions and variable profit functions greatly enhances agricultural policy analysis. The econometric applications of duality allow the empirical estimation of producers' output supply and factor demand functions. Without understanding these two aspects of producer response, analysis of a policy regime change is critically hindered.

The first applications of duality to economic analysis were done by Hotelling (1932) and Roy (1942) for consumer demand, and by Shephard (1953) and Samuelson (1954) for cost and production functions. McFadden (1972) generalized the work of Shephard to include profit and revenue functions.

The work of Diewert (1971, 1973, 1974); Christiansen, Jorgensen and Lau (1973); and Lau (1974, 1976) to develop flexible functional forms permits a highly disaggregated analysis of production structure. Traditional approaches required the aggregation of heterogeneous exogenous factors that may affect factor demands and output supplies differently. The combined use of duality theory with the flexible forms makes it possible to trace the impact of an array of environmental factors simultaneously (Sidhu and Banaante).

Following Mountain and Hsaio, a specification search for the "correct" functional form was performed, beginning with the simplest flexible parametric specifications, and proceeded in increasing order of complexity. When compared to the more popular general-to-specific approach, this technique reduces the computational burden since, in the former approach, there could be many more different routes of imposing restrictions. To choose the most appropriate specification, one begins by testing the most restrictive hypothesis. Thus, testing begins with the Cobb-Douglas specification, proceeds with the translog, and is followed by the Fourier functional form. For all tests, the alternate hypothesis is the homogeneous, unrestricted functional form of equations (1) and (2) below.

$$(1) \quad \begin{aligned} \ln\Pi^* = {} & \alpha + \Sigma_i b_i \ln P_i^* + b_{ij} \ln P_i^* \ln P_j^* \\ & - 2\{\Sigma_i [d_i \sin(\ln P_j^*) \\ & + e_i \cos(\ln P_i^*)]\} \end{aligned}$$

$$S_i^* = b_i + \Sigma_i b_{ij} \ln P_j^* \; 2\{\Sigma_i [d_i \sin(\ln P_i^*) - e_i \cos(\ln P_i^*)]\} \tag{2}$$

For the above demand system to be derived from a viable profit function, one of the following sets of restrictions must hold:

(a) constant (Cobb-Douglas) case, $d_i = e_i = b_{ij} = O \forall_{ij}$

(b) linear (translog) case, $d_i = e_i = 0,\ b_{ij} = b_{ji} \forall_{ij}$

(c) Fourier case $d_i = -d_j,\ e_i = -e_j,\ b_{ij} = b_{ji}$

From the general function (1), the normalized flexible profit function for dairy cooperatives may be specified as:

$$\begin{aligned} \ln \pi^* = {} & \alpha + \alpha_x \ln P_x^* + \alpha_k \ln P_k^* \\ & + \tfrac{1}{2} \gamma_{xx} \ln P_x^* \ln P_x^* \\ & + \gamma_{xk} \ln P_x^* \ln P_k^* \\ & + \tfrac{1}{2} \gamma_{kk} \ln P_k^* \ln P_x^* \\ & - 2[(\delta_x \sin \ln P_x^* + \phi_x \cos \ln P_x^*) \\ & + (\delta_k \sin \ln P_k^* + \phi_k \cos \ln P_k^*)] \\ & + \sum_{i=1}^{6} D_i \end{aligned} \tag{3}$$

where:

Π^* is normalized net savings (cooperative profits) with output price P_y as the numerator;

P_x^* is the normalized price of raw milk, a weighted FMMO blend price;

P_k^* is the normalized price of capital, bank of cooperatives annual average rate of interest;

D_i is a dummy variable, denoting the i^{th} cooperative.

Following the development of (2) the S_i^* function for raw milk and capital expenditures are obtained by differentiating (3) with respect to P_x and P_k.

$$\begin{aligned} S_k^* = {} & \alpha_k + \gamma_{kk} \ln P_k^* + \gamma_{xk} \ln P_x^* \\ & + 2[(\delta_k \sin \ln P_k^* - \phi_k \cos \ln P_k^*)] \\ & + \sum_{i=1}^{6} D_i \end{aligned} \tag{4}$$

$$\begin{aligned} S_k^* = {} & \alpha_k + \gamma_{kk} \ln P_k^* + \gamma_{xk} \ln P_x^* \\ & + 2[(\delta_k \sin \ln P_k^* - \phi_k \cos \ln P_k^*)] \\ & + \sum_{i=1}^{6} D_i \end{aligned} \tag{5}$$

where: $S_x^* = \dfrac{-P_x^* X_x}{\pi^*}$ and $S_k^* = \dfrac{-P_k^* X_k}{\pi^*}$

For all statistical tests, the Wald statistic with an F distribution will be used (Harvey, pp. 165-76). To balance the desirability of not estimating an overparameterized model with the sensitivity of the procedure for rejecting a false null hypothesis, a monotonically non-decreasing significance level for the more restrictive null hypotheses will be employed. Therefore, a 5 percent significance level is used for testing the Cobb-Douglas formulations. A one percent significance level is used to test the translog and Fourier specifications (Mountain and Hsaio).

Table 2 reports Wald statistics and critical values for each specification and all products against the unrestricted specification. A joint hypothesis was performed on the validity of imposing 26 (Cobb-Douglas), 18 (translog) and 12 (Fourier) restrictions to estimate jointly equations 3, 4, and 5. The Cobb-Douglas formulation was rejected for each product. Accordingly, the Fourier flexible form was chosen for milk and cheese estimates, and the translog specification was chosen for butter and powder estimates.

Each model was estimated by the iterative Zellner (1962) efficient technique. Coefficient estimates and diagnostic statistics are reported in Table 3. These estimates form the basis for deriving output supply elasticity estimates for milk, cheese, butter, and powder and the associated factor demand elasticities for raw milk and capital expenditures. All elasticities are evaluated at

Table 2. Wald Statistics and Critical Values.

	Cobb-Douglas	Translog	Fourier
Ho:	$\delta_{ij} = \phi_{ij} = 0$ $\gamma_{ij} = \gamma_{ji} = 0$	$\delta_{ij} = \phi_{ij} = 0$ $\gamma_{ij} = \gamma_{ji}$	$\delta_{ij} = -\delta_{jj}$ $\phi_{ij} = -\phi_{jj}$ $\gamma_{ij} = \gamma_{ji}$
F(m, T-k)	$F_{.05}(26,47)$	$F_{.01}(18,47)$	$F_{.01}(12,47)$
Critical Value	1.85	2.84	3.62
Computed Values:			
Milk	3.01	2.98	1.13
Cheese	3.91	3.23	2.07
Butter	2.28	2.02	-
Powder	2.09	2.33	-

Table 3. Seemingly Unrelated Regression Equations: Profit Function Estimates and Diagnostic Statistics for Each Product

FOURIER FLEXIBLE FORM:

	CONST	Price of Raw Milk	Capital	PX^2	PXK	PK^2
Milk						
Coefficient	-29.5089	-6.2419	-2.4960	2.1476	3.2975	17.9152
Std. Error	11.5765	30.3847	1.1222	.1178	2.4767	24.8757
t-Stat.	-2.5490	-2.8384	-2.2244	18.2389	1.3315	.7202
P-value	.013	.006	.03	0	.188	.474
Cheese						
Coefficient	2.6798	-5.1710	-2.5419	.6544	6.3186	45.9040
Std. Error	1.2977	.0493	86.1370	.0686	2.5767	3.1017
t-Stat.	2.0650	-104.9172	-.0295	9.5435	2.4521	1.6334
P-value	.043	0	.977	0	.017	.107

TRANSLOG FLEXIBLE FORM:

	CONST	Price of Raw Milk	Capital	PX^2	PXK	PK^2
Butter						
dCoefficient	2.7852	-5.0843	- 4.3081	.4786	16.2940	155.4061
Std. Error	.8285	.1213	34.2335	.0649	2.6378	28.6012
t-Stat.	3.36148	-41.90091	-.1258	7.37336	6.1769	5.4335
P-value	.001	0	.9	0	0	0
Powder						
Coefficient	3.2953	-4.5595	-5.4695	.3117	19.7665	169.4401
Std. Error	1.1744	.0978	36.1547	.0517	2.1855	23.3246
t-Stat.	2.8058	-46.6211	-.1512	6.0272	9.0440	7.2644
P-value	.007	0	.88	0	0	0

Table 4. Derived Output Supply and Factor Demand Elasticities for Fluid Milk and Milk Products.

	FLUID MILK			CHEESE		
	Output Price	Raw Milk Price	Capital Expenditures	Output Price	Raw Milk Price	Capital Expenditures
Translog Specification:						
SUPPLY	0.7798	-0.6495	-0.1303	0.7107	-0.5963	-0.1244
RAW MILK	1.4017	-0.9947	-0.4047	1.4418	-0.8638	-0.5780
CAPITAL	0.5872	-0.0778	-0.5094	0.5800	-0.1200	-0.4600
Cobb-Douglas Specification:						
SUPPLY	0.7182	-0.4152	-0.3030	0.8186	-0.6710	-0.1476
RAW MILK	1.7182	-1.4152	-0.3030	1.8186	-1.6710	-0.1476
CAPITAL	1.7182	-0.4152	-1.3030	1.8186	-0.6710	-1.1476

	BUTTER			POWDER		
	Output Price	Raw Milk Price	Capital Expenditures	Output Price	Raw Milk Price	Capital Expenditures
Fourier Specification:						
SUPPLY	0.7677	-0.4283	-0.3394	0.8475	-0.7110	-0.1365
RAW MILK	1.7034	-1.5956	-0.1078	1.6187	-0.9180	-0.7007
CAPITAL	0.7359	-0.1464	-0.5895	0.6936	-0.1774	-0.4622
Cobb-Douglas Specification:						
SUPPLY	0.5182	-0.3870	-0.1312	0.7606	-0.4594	-0.3012
RAW MILK	1.5182	-1.3870	-0.1312	1.7606	-1.4594	-0.3012
CAPITAL	1.5182	-0.3870	-1.1312	1.7606	-0.4594	-1.3012

Table 5. Dairy Policy Impacts Upon Operational Performance and Output Supply Response, 7 Cooperative Average, 1980-1988.

Actual Operations Statement

	1980-1983	1984-1985	1986-1988
Gross Sales	$9737195.0	$10166244.2	$9325946.7
Cost of Sale	8911289.2	9341268.5	8553202.8
Taxes, Ins. and Interest	44552.8	71156.6	44175.3
Operating Expenses	695607.8	693909.0	650970.7
(1) Net Savings	77597.8	85745.0	59910.0
Cash Refund	15519.5	17149.0	11982.0
(2) Cash Payment/Member	1895.2	2094.2	1463.2

Operations Statement in Absence of Policy Change

	1980-1983	1984-1985	1986-1988
Gross Sales	$10344153.5	$10576541.2	$9695254.2
Cost of Sales	9504740.7	9679442.4	8891909.6
Taxes, Ins. and Interest	72401.9	48393.3	45924.7
Operating Expenses	706052.4	755569.2	676749.1
(3) Net Savings	60958.4	93136.2	80670.7
Cash Refund	16134.1	18627.2	12191.6
(4) Cash Payment/Member	1970.3	2274.7	1488.8

Average Annual Cooperative Supply Response to Output Price Changes

\- 1,000,000 lbs. -

Cooperative Supply

Fluid Milk	Cheese	Butter	Powder
3069.7	1006.8	511.12	84.24

Cooperative Supply in Absence of Policy Change

	Fluid Milk	Cheese	Butter	Powder
1980-1983	3111.84	1022.18	518.03	85.49
1984-1985	3320.96	1102.42	552.32	91.74
1986-1988	3423.74	1142.32	569.16	94.82
1980-1988	3285.5	1088.97	546.5	90.51
Net Change (%)	7.0	8.2	6.9	7.4

simple averages for S_i* and at geometric means of the variable input price and of the level of the fixed input.

Estimates of cooperative milk and milk products supply and factor demand elasticities for raw milk and capital are valuable results in themselves. These can be applied directly to assess the impact of a variety of micro-policy actions (Sidhu and Banaante). Table 4 presents the elasticity estimates for each product derived from the parameters of that functional form specified in Table 3. For the sake of comparison, elasticity estimates from the parameters of the Cobb-Douglas specification are also reported. Because the Cobb-Douglas function has the characteristic of constant unitary elasticity of substitution among all input prices, the impact of a given change in an exogenous variable is symmetric across the factor demands. The impact of a similar change in the flexible forms, however, varies across the factor demand equations and is consistent with a priori theoretical expectations. For example, increases in the output price of each product expands the output supply of the product as well as the demand for raw milk and capital expenditures. On the other hand, increases in the raw milk price or the price of capital has a debilitating effect on the demand for these factors. Moreover, raw milk demand is considerably more responsive to price changes than are capital outlays.

A variety of policy analyses are possible with the use of the estimates of Tables 3 and 4. Computing revenue gains and losses as well as changes in production levels is straightforward, given policy price changes in the Federal Milk Marketing Order (FMMO) system, since milk products are tied directly to it. There are, of course, milk and milk products produced in states that do not belong to a FMMO--California being the principal example. However, no California cooperatives are included in the present sample.

Table 5 provides estimates of changes in cooperative net revenues and production levels resulting from dairy policy changes since 1980. Changes are reported for three periods to coincide with the principal policy price adjustments of the period. The Dairy Herd Buy-out and the Milk Diversion programs are accounted for by adjusting cooperative throughput by regional participation levels in these programs. Program participation reduced regional production and marketings by known rates. So also was the percentage of total milk produced that was handled by cooperatives for each region. Cooperative throughput then was adjusted by including the cooperative portion of program participation.

By summing line item (3) (in Table 5) across each of the policy periods and subtracting the sum of (1), the effects of policy change upon the average net savings of the seven cooperatives are calculated. By this estimate then, about $13.8 million additional would have been received by the seven had policies not changed during the period.

The effect of policy change on the cash payment per member is computed similarly by summing line (4) and subtracting the sum of line (2). Foregone cash patronage refunds averaged about $2,800.

Cooperative supply in absence of policy change is compared to actual output by a simple average of each of the three policy periods for the four products. Thus, had policies not changed during the period, the seven cooperatives would have processed 7 percent more fluid milk, 8.2 percent more cheese, 6.9 percent more butter and 7.4 percent more non-fat dried milk powder on average.

Conclusions and Implications for the Food Industry

This paper combines duality theory with flexible, functional form estimations to trace the impact of policy changes upon dairy cooperatives. Parameters of dairy product models, based on the normalized profit function and the derived system of demands, were estimated using Operations and Finance data from seven prominent U.S. dairy cooperatives. Empirical results demonstrate the plausibility of each chosen specification and show a lack of validation of the Cobb-Douglas specification in each case. Output supply elasticities and factor demand elasticities were derived from the parameters of the chosen specification for fluid milk, cheese, butter and non-fat dried milk powder.

Using historical policy price changes and known producer response to supply management policies of the period, cooperative operations statements were computed using counter factual production levels that were generated by the derived elasticities. On average, approximately $13.8 million in revenue was foregone by the seven sample cooperatives as a consequence of reduced throughput and lower output prices during the period. This amounts to a foregone cash dividend of $2,800 per cooperative member. Average annual processing of fluid milk, cheese, butter and powder may have been 7, 8.2, 6.9 and 7.4 percent higher, respectively, among the seven cooperatives were it not for the dairy policy changes of the period.

This procedure may also provide ex-ante analysis of cooperative response to policy changes when combined with forecasts of output and factor price adjustments that result from policy shocks. The next step of this research program involves constructing a Vector Auto Regression model, composed of various policy/price instruments which are known to drive the milk price complex. Once the price impacts of the proposed changes are obtained, the output supply and factor demand elasticities described above will be employed to compute the potential gains or losses to cooperatives.

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