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INCORPORATING PRICE REGULATION IN CAUSALITY TESTS FOR DAIRY MARKETS

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INCORPORATING PRICE REGULATION
IN
CAUSALITY TESTS FOR DAIRY MARKETS

Paula A. Emerick, Lois Schertz Willett, and Andrew M. Novakovic*

Abstract

Price relationships across market levels have become an issue of concern in dairy markets as lower support levels have led to increased price volatility. This study analyzes price causality in the presence of price regulation. Specific causal relationships are estimated and are not generally affected by regulated prices.

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INCORPORATING PRICE REGULATION IN CAUSALITY TESTS FOR DAIRY MARKETS

INTRODUCTION

Since 1988, milk prices have been highly volatile, particularly in comparison to historical patterns. In times of large and rapid declines in farm prices, producers have been critical of processors and retailers for not reflecting the change in wholesale and retail prices. This paper explores causality in dairy product markets. Previous studies examining the price transmission processes of dairy product prices assume the causal order flows unidirectional upward from the farm to the retail market level (Kinnucan and Forker); however, intuitive reasoning suggests the plausibility of other possibilities. Causality tests are available to test this assumption and provide statistical evidence for the causal ordering between variables.

Causality tests of time series data are based on a simple concept of predictability -- past information of one variable increases the ability to predict another variable. Since Granger introduced his theoretical concept of testing for causality in 1969 and Sims modified and tested empirically for causality in 1972, many applications of these tests have appeared in economics and agricultural economics literature (Sarker). In agricultural economics, studies of the price relationships at different market levels have been prominent. Although several authors have questioned the validity of causality testing (e.g. Zellner, Conway, et al.), it continues to be a popular applied research method.

Dairy product and milk prices are or may be heavily influenced by federal price supports and regulations (Novakovic). Under the dairy price support program (DPSP), a federal support price for grade B milk is set and from that farm price wholesale prices are established at which USDA stands ready to purchase an unlimited amount of cheddar cheese, butter, and nonfat dry milk offered by sellers, provided the product meets specific product and packaging standards. The support price is a policy target, the purchase prices are policy instruments. As such, purchase prices can and do have a direct influence on the level of wholesale prices in periods when product surpluses exists. Their impacts on wholesale markets affect farm, retail, and collateral wholesale markets indirectly. The federal milk marketing order program (FMMO) regulates prices paid by milk processors covering about 70% of the U.S. milk supply. Under this program, minimum prices are announced monthly which apply to milk according to its usage. Prices for milk used for fluid purposes are announced about one month in advance of their applicability; prices for milk used for "soft" dairy products (including ice cream) are announced about two weeks in advance. Prices for "hard" dairy products (including butter, nonfat dry milk, and cheese) are announced several days following the month to which they apply. The possibility of purchase prices directly impacting wholesale prices for the corresponding products and the possibility of FMMO minimum prices directly impacting the level and timing of farm prices adds an uncommon dimension to the analysis of causality in dairy product markets.

The objective of this research is to determine the direction of causality and the role of government regulated prices in dairy market price transmission processes. To achieve this three market levels--farm, wholesale, and retail--are analyzed for five dairy products. These products are: 1) fluid milk, 2) processed cheese, 3) butter, 4) nonfat dry milk, and 5) ice cream. The effects of government purchase prices for (2), (3), and (4) and minimum class I and class II prices are also studied.

DATA

Monthly price data provided by the U.S. Department of Agriculture and the Bureau of Labor Statistics for the 1971-1991 time period are included in the analysis. National average prices for all three market levels exist only for butter and processed cheese. Farm and wholesale prices exist for nonfat dry milk. National data for fluid milk and ice cream represent the farm and retail levels. Based on federal milk marketing order regulations and industry practices, different farm level prices apply to different sectors. Hence the class III price is used for butter, processed cheese, and nonfat dry milk markets. The class I price is used for fluid milk markets, and the class II price for heavy cream (40% milkfat) is used for ice cream markets (see Novakovic for a more detailed discussion).

METHODOLOGY

Several studies have analyzed causality using the Granger or Sims methods (Heien; Lamm and Westcott; Ward; Colclough and Lange; Jones; Blank and Schmiesling). However, the modified Sims test has been popular in recent literature. Monte Carlo tests, performed by Geweke, et al. and Zapata, et al., suggest that the modified Sims and Granger tests perform well under the controlled conditions.

The modified Sims test includes past values of the dependent variable in addition to past, current, and future values of the independent variable. The ordinary least squares (OLS) method is used to estimate two equations, with and without future values. A joint

F-test is calculated; if the value is significant, causality flows from the independent to the dependent variable.

Neither the general form of the tests nor theory determine the appropriate length of lead and lag relationships. Based on practical knowledge of dairy markets, we judged that a maximum four month lead and lag was adequate. Longer lags were briefly explored and did not seem to result in additional useful information. Jones suggests that the number of lags equal the number of leads for the independent variable in order not to introduce a spurious asymmetric relationship (p. 46).

Government purchase prices and support prices are included in the appropriate equations to test if the existence of a regulated price affects causality. Due to the discrete and abrupt nature of changes in the DPSP variables (usually once per year), these prices are modeled by dividing each price into two variables. One variable is the cumulative marginal increases in price; the other is the cumulative marginal decreases in price. The corresponding purchase price is included when the dependent variable is the wholesale price of a government supported product. Similarly, the support price is included when the Minnesota-Wisconsin (or class III) price is the dependent variable.

The regression equations used to determine causality are of the following form:

$$Y_t=\alpha_0+\sum_{j=0}^{4}\alpha_j X_{t-j}+\sum_{k=1}^{4}\gamma_k Y_{t-k}+\sum_{t=0}^{n}\zeta_t \Delta PP_{up}+\sum_{t=0}^{n}\eta_t \Delta PP_{down}+\delta TR+\epsilon_{1t} \quad (1)$$

$$Y_t=\beta_0+\sum_{j=-4}^{4}\beta_j X_{t-j}+\sum_{k=1}^{4}\gamma_k Y_{t-k}+\sum_{t=0}^{n}\zeta_t \Delta PP_{up}+\sum_{t=0}^{n}\eta_t \Delta PP_{down}+\delta TR+\epsilon_{2t} \quad (2)$$

where the purchase price (PP) is measured over the sample period n and TR is a trend term. The error terms are assumed uncorrelated.

The null hypothesis that Y does not cause X (i.e. no causal relationship between dependent and independent variables) is represented by the equation

$$\beta_j = 0 \textit{ for all } j < 0 \tag{3}$$

which can be tested using a joint F-test of (1) and (2), where (1) is the restricted equation and (2) is unrestricted (see Sarker for test statistic). Rejection of the null hypothesis suggests that a statistically significant relationship exists between the two price variables. The variables can be reversed to check for causality in the opposite direction.

Statistical causality is evaluated under four scenarios. First, no purchase or support prices are included in the analysis corresponding to the general form of causality tests. Second, support program prices are included for the hard manufactured products. Third, the timing of the farm price announcement is examined for fluid milk and ice cream. The farm price series for these products are shifted one month to coincide with the month in which the class prices are announced, as opposed to the date they take effect. Finally, the data set is split into two periods; 1971-1987 and 1988-1991. Although the government began to reduce the support price in late 1983, extreme departures from the usually similar movements of the benchmark Minnesota-Wisconsin (M-W) price and the support price began in 1988. A comparison of the coefficients under two data periods might suggest a change in structure resulting from the fact that much lower support prices since 1988 have led to a lack of surplus conditions in all dairy product sectors except butter. Cumulative marginal purchase prices and the support price are included in this last scenario.

For the three manufactured and government-supported dairy products, it is hypothesized that the wholesale market price leads both the farm and retail prices (Novakovic, p. 4). This is due to the U.S. government role in supporting dairy prices, the process for setting class III prices and perceived industry practices. For the fluid, soft dairy products (i.e. fluid milk and ice cream), it is hypothesized that the dominant price pattern is from the farm level to the wholesale level to the retail level (Novakovic, p. 5).

EMPIRICAL RESULTS

In the first scenario under which purchase and support prices are not included in the analysis, the results are as follows. Fluid milk prices are bidirectional between farm and retail prices; that is, statistical evidence shows that price flows between the two series are significant.[1] Butter prices flow from the wholesale to the farm price, and from the wholesale to the retail price. In addition, the relationship between farm and retail prices is characterized by bidirectional causality. Processed cheese prices flow from the wholesale to the retail level, and from the farm to the retail level. Bidirectional causality is found to occur between the farm and wholesale prices of processed cheese. Likewise

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[1] Two prices were used to approximate the price paid by processors for fluid milk: the FMMO minimum class I price and the class I price announced by cooperatives, as reported by USDA. Similar results were found; only FMMO class I price results are discussed here.

for nonfat dry milk, bidirectional causality is found between the farm and wholesale prices. Ice cream prices flow from the farm to the retail level.[2]

The calculated F values for the second, third, and fourth scenarios are reported in Table 1. Figures of the results for each product and scenario are also included in Table 1. Under the second scenario in which cumulative marginal values of purchase and support prices are included in the regressions, the results differ only slightly from the base scenario results. Butter prices flow from the wholesale to the retail price, and bidirectionally between farm and retail prices. No statistically significant causal relationship exists between the farm and wholesale price of butter. For processed cheese, inclusion of the purchase and support prices does not change the causal ordering from the first scenario. Bidirectional causality exists between farm and wholesale prices, and unidirectional causality is found from wholesale to retail prices and farm to retail prices. Similarly for nonfat dry milk, bidirectional causality between farm and wholesale prices exists.

Under the third scenario, the farm price data for fluid milk and ice cream are literally shifted back one period to examine the effect of prior knowledge of the farm prices due to the advance price announcement. The results do not differ from the base scenario results. Even when the data are shifted, there is a curious lack of change in the

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[2] Two prices were used to represent the price of milk used to make ice cream mix: the class II price of milk (3.5% fat) and the class II price of heavy cream (40% fat). Similar results were found. The 40% class II price results are presented.

"contemporary" price parameter. For fluid milk, bidirectional causality exists between the farm and retail prices under both variations of the farm price. Ice cream prices exhibit unidirectional causality from the farm to the retail price for both variations of the farm price.

In the fourth scenario in which the data set is split into the two time periods, fluid milk results vary slightly from the base scenario. In the early time period, unidirectional causality exists from the farm to the retail price. In the more recent time period, bidirectional causality from retail to farm prices is found.

In the early time period, the causal ordering of butter is similar to the results under the base scenario. All base relationships exist except no causality exists from retail to farm prices. In the later time period no statistically significant relationships exist between any of the price series.

For processed cheese, the results differ not only in each time period but also from the base scenario. In the early time period, prices flow from the wholesale to the retail price and from the farm to the retail price of processed cheese. No causal relationship exists between the farm and wholesale prices. In the more recent time period, bidirectional causality exists between the farm and the wholesale prices, and unidirectional causality from the farm to the retail price. No causal relationship exists between the wholesale and retail price.

The causal ordering of nonfat dry milk does not differ from the early time period to the late time period. Bidirectional causality exists between farm and wholesale prices.

Unidirectional causality from farm to retail prices exists for ice cream. This results holds under both early and late time periods.

In the fourth scenario, fluid milk, butter, and cheese markets show different patterns of causality. When the early and late orderings are meshed together, the end result is equivalent to the base scenario. A structural change in the dairy industry is suggested by this occurrence. This conclusion concurs with the discussion above; prior to 1988 dairy product price changes generally were consistent with government program price changes, while after 1988 prices became much more volatile and market-oriented.

Statistical results suggest that the contemporaneous purchase and support prices are insignificant. However, this does not mean that no effect exists. Any lead or lag relationship may be hard to identify due to the timing and dynamics of when an announcement is made regarding a purchase or support price change.

The statistical significance of the cumulative marginal increases and decreases for the purchase prices and support price are varied. Results suggest that although the purchase prices or support price can be significant in explaining the wholesale price of butter, processed cheese, or nonfat dry milk, neither the cumulative marginal increases or decreases of these prices influence the direction of causality for the government-supported products.

CONCLUSIONS AND EXTENSIONS

Implications for the dairy industry and the dairy price support program are suggested with the testing of causality. Most importantly, the causal relationships between the prices depend upon the data period examined; a relationship that is statistically significant in one period may or may not be so in another period. Thus, it is appropriate to separate recent price patterns from historical patterns.

Second, as discussed above, the government purchase and support prices do not influence the direction of causality even though these prices might be significant variables in explaining the appropriate price level.

Third, early announcement of the class I and class II farm prices for milk does not change the direction of causality for fluid milk and ice cream.

Finally, the relationships between the five dairy products are complex. A price may be formed from a combination of other prices (e.g. causality flows from both farm and wholesale price to the retail price of processed cheese), and the effects of each price are difficult to separate. Thus it would be incorrect to assume that a price is statistically caused by only one other price.

Further study of causal relationships might examine the dynamics of <u>when</u> the purchase or support prices are announced. The length of notice may affect the statistical significance of these prices and/or the causal ordering of market level prices.

Additional study could focus on regional patterns, which may differ from the national results.

Furthermore, the results reported here could be compared with estimates derived from alternative techniques used to evaluate causality.

Table 1. F-Statistic for Modified Sims Causality: Farm, Wholesale, and Retail Prices

	F[1]→W[1]	W→R[1]	F→R	W→F	R→W	R→F	RESULTS SUMMARY
FLUID MILK							
Shift[2]:	na	na	18.80^{*}_{h}	na	na	5.38^{*}_{g}	**F <-> R**
Early[4]:	na	na	8.18^{*}_{e}	na	na	3.96^{*}_{e}	**F <-> R**
Late[5]:	na	na	2.09_{c}	na	na	6.18^{*}_{c}	**F <- R**
BUTTER							
Prices[3]:	1.04_{f}	57.05^{*}_{f}	7.49^{*}_{f}	1.64_{f}	0.74_{h}	3.30^{*}_{h}	<------> **F W-> R**
Early[4]:	0.38_{d}	49.76^{*}_{d}	16.53^{*}_{d}	3.57^{*}_{d}	0.82_{e}	0.96_{e}	------> **F <-W-> R**
Late[5]:	0.33_{a}	2.29_{b}	0.59_{a}	1.75_{b}	0.62_{c}	0.75_{c}	**F W R**
PROCESSED CHEESE							
Prices[3]:	8.92^{*}_{f}	16.21^{*}_{f}	27.83^{*}_{f}	4.47^{*}_{f}	1.70_{h}	1.83_{h}	------> **F<->W-> R**
Early[4]:	1.43_{d}	23.65^{*}_{d}	30.27^{*}_{d}	1.16_{d}	1.33_{e}	0.50_{e}	------> **F W-> R**
Late[5]:	3.72^{*}_{a}	1.27_{a}	4.05^{*}_{a}	2.85^{*}_{a}	1.66_{c}	1.95_{c}	------> **F<->W R**

Table 1. (continued)

	F→W	W→R	F→R	W→F	R→W	R→F	RESULTS SUMMARY
NONFAT DRY MILK							
Prices[3]:	5.79^{*}_{f}	na	na	34.23^{*}_{f}	na	na	**F<->W**
Early[4]:	3.67^{*}_{d}	na	na	3.65^{*}_{d}	na	na	**F<->W**
Late[5]:	2.97^{*}_{a}	na	na	8.88^{*}_{b}	na	na	**F<->W**
ICE CREAM							
Shift[2]:	na	na	3.33^{*}_{h}	na	na	0.52_{g}	**F -> R**
Early[4]:	na	na	3.20^{*}_{e}	na	na	0.56_{e}	**F -> R**
Late[5]:	na	na	6.60^{*}_{c}	na	na	0.22_{c}	**F -> R**

* The F-Statistic is significant at the 95% confidence level under the following degrees of freedom: a: 4,27; b: 4,28; c: 4,29; d: 4,183; e: 4,185; f: 4,227; g: 4,228; h: 4,229.

1 F=Farm, W=Wholesale, R=Retail

2 Farm price shifted back one month.

3 Cumulative marginal purchase price or support price increases or decreases included.

4 1971 to 1988.

5 1988 to 1991.

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