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APPLIED COMMODITY PRICE ANALYSIS, FORECASTING AND MARKET RISK MANAGEMENT

Examining Changes in Dairy Product Price Relationships Due to Increasing Price Volatility

by

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Rationale of Study

Various aspects of dairy product price relationships have been examined in the past, but the period since 1988 offers an opportunity to examine these relationships in a new environment. For most of the time since the Dairy Price Support Program was enacted in 1949, market prices for milk and dairy products have been driven, if not set, by federal supports. Since 1988, the support price for milk has been at a level so low as to be virtually ineffective. What has emerged is an unstable price pattern that deviates markedly from traditional patterns of seasonality and range. In this volatile environment, it is not surprising that the once-somnolent domain of dairy price processes has become enlivened with concerns and discussions about public policy related to farm-retail price relationships and business policies related to risk management. The purpose of this study is to systematically measure how dairy market prices are related to one another and whether these relationships have fundamentally changed since 1987.

In the late 1970s, the main objective of federal dairy policy was to provide adequate dairy farm incomes through milk prices supported at levels high enough to match input price inflation. To achieve this, Congress, following the lead of President Carter, passed legislation requiring semi-annual increases in the support price for milk and a minimum level of 80 percent of parity in the government's price target. The Minnesota-Wisconsin (M-W) price, the basic price mover for all farm milk prices, followed very closely the increases in the support level. The support price peaked at $13.10 per cwt (3.67 percent milkfat) from 1981 to 1983. By this time, it was difficult to even hold the M-W at the level of the support price. Surpluses in excess of 10 percent of the U.S. milk supply became common and government expenditures exceeded a billion dollars.

The desire to reduce government expenditures precipitated a shift in dairy policy in the early 1980s. In December 1983, the support price was lowered for the first time in over 30 years. Lower support levels were intended to lead to fewer government purchases, less government expenditure and more market-oriented dairy markets. The support level was continually decreased until mid-1990 at which time it was $10.10 per cwt (3.67 percent milkfat).

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Greater volatility in the M-W, especially since 1988, was due to changing market supply and demand conditions and the underlying forces of weather and dairy policies (Gardner, in *Review of Farm-to-Retail...*). First, lower (or slowing) production occurred due to lower support levels and the effects of the Dairy Termination Program. With lower support levels (and a lower effective price "floor"), the range increased over which milk prices could move --in either direction-- in response to changes in milk production. Then, world supplies of nonfat dry milk (NDM) decreased after European milk and powder were tainted from the Chernobyl nuclear accident. Inventory holdings of the European Community and the U.S. were depleted, and record high nonfat dry milk prices followed normal demand but low supply levels. This was in stark contrast to previous decades when NDM prices literally rode on government support levels. Cheese demand was also growing strongly; the relative lack of supplies of both products drove up the M-W and consequently all milk prices in 1989. Finally, these high prices were followed by increases in milk production. The demand for U.S. nonfat dry milk exports and cheese fell as European supplies rebounded and inventories were rebuilt. Prices fell as quickly as they had risen.

The contrast of this erratic behavior to earlier patterns is shown in Figure 1. The M-W price and the support price have traditionally moved together, but since 1988, extreme price swings in the M-W have become the norm. Unaccustomed to these wild price swings which make short- and long-term business decisions difficult, many dairy producers went out of business. Industry advocates argued that the basic objectives of federal dairy policy were not being met. Volatile prices have continued in 1992 and 1993, although not to the extent witnessed between 1989 and early 1991.

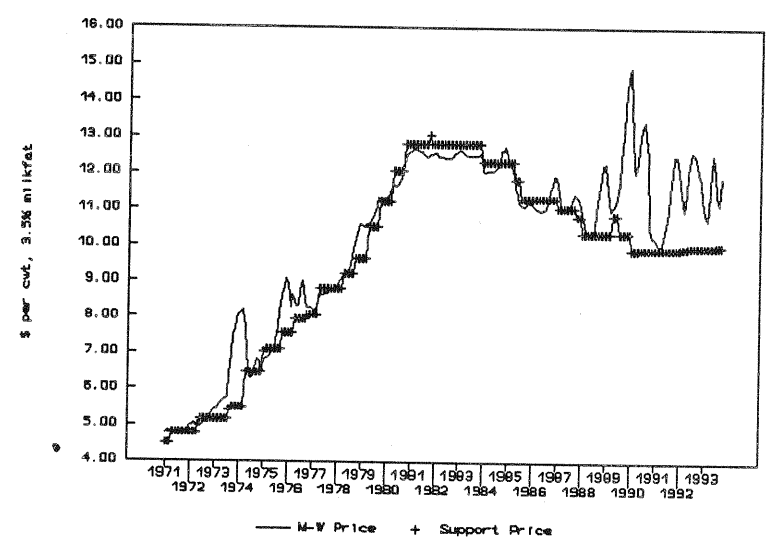

Figure 1
M-W Price vs. Support Price, January 1971 - September 1993

The supposed connections between prices at the farm, wholesale, and retail levels for various products have been questioned as retail prices did not exhibit the price swings felt at the farm level, especially on the down side. For example, the farm price of milk used to make processed cheese (**PMW**) and the retail processed cheese price (**PPCR**) in cents per pound for 1981 through 1991 are shown in Figure 2. The retail price did not fluctuate up and down nearly as much as did the farm price in the late 1980s. Also, in mid- to late-1989, the retail price increased at a greater rate than it had previously, reflecting the large jump in the farm price. However, in late 1990 and 1991, the retail processed cheese price did not reflect, to the same extent, the large downward-turn in the farm price of milk used in manufacturing barrel cheese. Similar relationships between the farm-level and retail-level prices existed for other dairy products, in which it appeared that during the latter part of the 1980s and early 1990s, the retail level did not fluctuate as much as the farm price; retailers were faster to pass on cost increases to consumers in comparison to cost decreases.

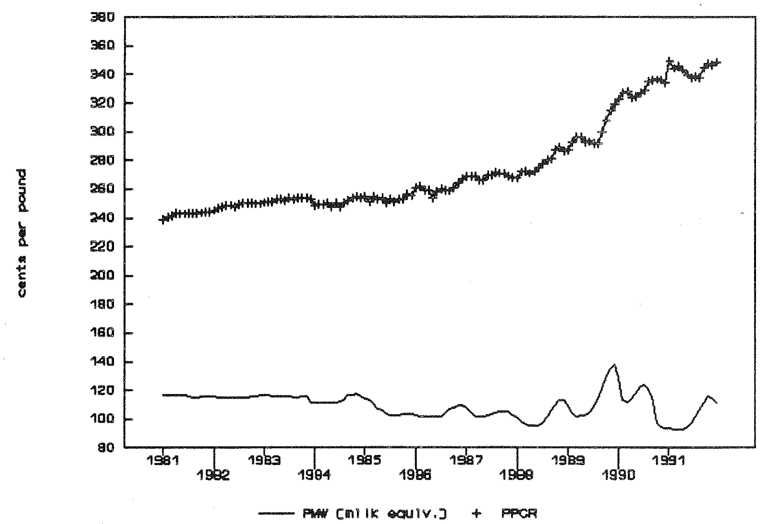

Figure 2
Farm and Retail Processed Cheese Prices, 1981-91

Representatives from government, academia, and all levels of the dairy industry testified before a 1991 Congressional subcommittee hearing which attempted to review the farm-to-retail pricing and marketing relationships in the U.S. dairy industry. The instability of dairy prices provided a new opportunity to explore dairy product price relationships. Specifically, the subcommittee wanted (1) to know what the "normal" relationships were among farm, wholesale, and retail dairy prices and (2) to address concerns that recent retail prices of milk and milk products, especially cheese, had not responded to declines in farm prices (*Review of Farm-to-Retail...*).

In this examination of price relationships for five dairy products, five major objectives exist. Econometric techniques are used to analyze monthly national average price data to achieve these objectives for the following products: fluid milk, processed cheese, butter, nonfat dry milk, and ice cream.

1. Establish statistically significant relationships which describe causal linkages across market levels (farm, wholesale, and retail) for major dairy products.
2. Given the estimated directions of causality, measure intermarket price relationships using a price transmission, marketing margin model approach.
3. Evaluate the symmetry of price relationships across market levels.
4. Examine the possibility of changes in price relationships since 1988.
5. Determine the role of federal purchase prices and/or advance pricing in federal orders on price relationships.

Causality Tests

Causality tests were used to establish statistical linkages between the farm, wholesale, and retail levels for each of the dairy products. The modified Sims or lagged dependent variable methodology (Geweke, et al (1983)), a modification of Granger (1969) and Sims (1972) causality tests, was used to test for statistically significant evidence of "causality" or "predictability" between the market level prices. Due to the government's indirect involvement in supporting the price for milk through its willingness to purchase manufactured products via the CCC, the wholesale price level was hypothesized to lead the retail and farm prices for these supported products (i.e. F ← W → R). Non-supported products (fluid milk and ice cream) have farm prices announced two to four weeks prior to the month they take effect; hence, prices were hypothesized to move upward through the marketing channel from the farm to the retail level (i.e. F → W → R). However, all possible combinations of prices were tested (i.e. from farm to wholesale (F → W), wholesale to retail (W → R), farm to retail (F → R), and vice versa for each pair) for each product.

In addition to testing the causal order for the entire sample period, 1971-91, three other situations were tested to examine whether causal connections differed from the base results (cf. objectives 4 and 5). First, government support and purchase prices were included in the equation specifications for the supported products: processed cheese, butter, and nonfat dry milk. Second, the announcement date, prior to the effective date of the class I and class II prices, was considered for fluid milk and ice cream. Third, the sample period was divided in two sub-periods, 1971-87 and 1988-91, to test whether differences in seasonal pricing stability resulted in different causal flows. A summary of causality results is contained in Table 1.

The general results of the causality tests are:

(1) differences exist across products;

(2) causal flows are multi-directional;

(3) a structural change occurred circa 1988 when the price support reached a level so low it no longer supported milk prices;

(4) governmental support and purchase prices do not appear to influence the causal order (with the exception of butter), even though these prices might be significant variables in explaining the appropriate price level;

(5) the causal relationships for fluid milk and ice cream proceed equally well from the date of effectiveness or date of announcement of class I and II prices;

(6) differences do exist, sometimes significantly, from the early to the late sub-periods for three of the five dairy products; and

(7) the early and late period causality results combined are the same as the results from the total pooled sample in all but one case. The exception was butter where the presence of causality from the retail to farm price was negated in the pooled data.

Table 1
RESULTS OF CAUSALITY TESTS

PRODUCT	CASE[1]				
	Base 1971-91	Shift	Gov't Prices	Split 1971-87	Split 1988-91
Fluid Milk	F ←---→ R	F ←→ R	n/a	F ---→ R	F ←--- R
Proc. Cheese	F ↔ W → R [F - - → R]	n/a	F ↔ W → R [F - - → R]	F W → R [F - - → R]	F ↔ W R [F - - → R]
Butter	F ← W → R [F ← - - → R]	n/a	F W → R [F ← - - → R]	F ← W → R [F - - → R]	F W R
Nonfat Dry Milk	F ←---→ W	n/a	F ←---→ W	F ←---→ W	F ←---→ W
Ice Cream	F ←---→ R	F ←→ R	n/a	F ←---→ R	F ←---→ R

[1] F, W, R represent farm, wholesale, and retail prices, respectively.

Price Transmission Model

With the base case results of the causality tests, a framework for dairy price transmission was formulated and estimated. Due to the multi-directional aspect of the causality results, a simultaneous system of equations was formed by most of the product prices. The simultaneous system was estimated (with SAS-ETS) using three-stage least squares to account for cross-equation correlation of errors and to yield efficient estimates. For recursive equations, ordinary least squares estimation was used. If autocorrelation was apparent, OLS with an autocorrective procedure was used to estimate the recursive equations. A distributed lag structure was chosen for all equations. Individual lag lengths were chosen for each product (generally 2 or 3 months, based on knowledge of dairy markets); longer lag lengths (up to six months) were explored but added no significant value to the estimation. The system of prices is shown in Figure 3. Definitions for the price transmission variables are in Table 3. The direction of the arrow indicates that price flows from one variable to the other (e.g. from **PPCW** to **PPCR**).

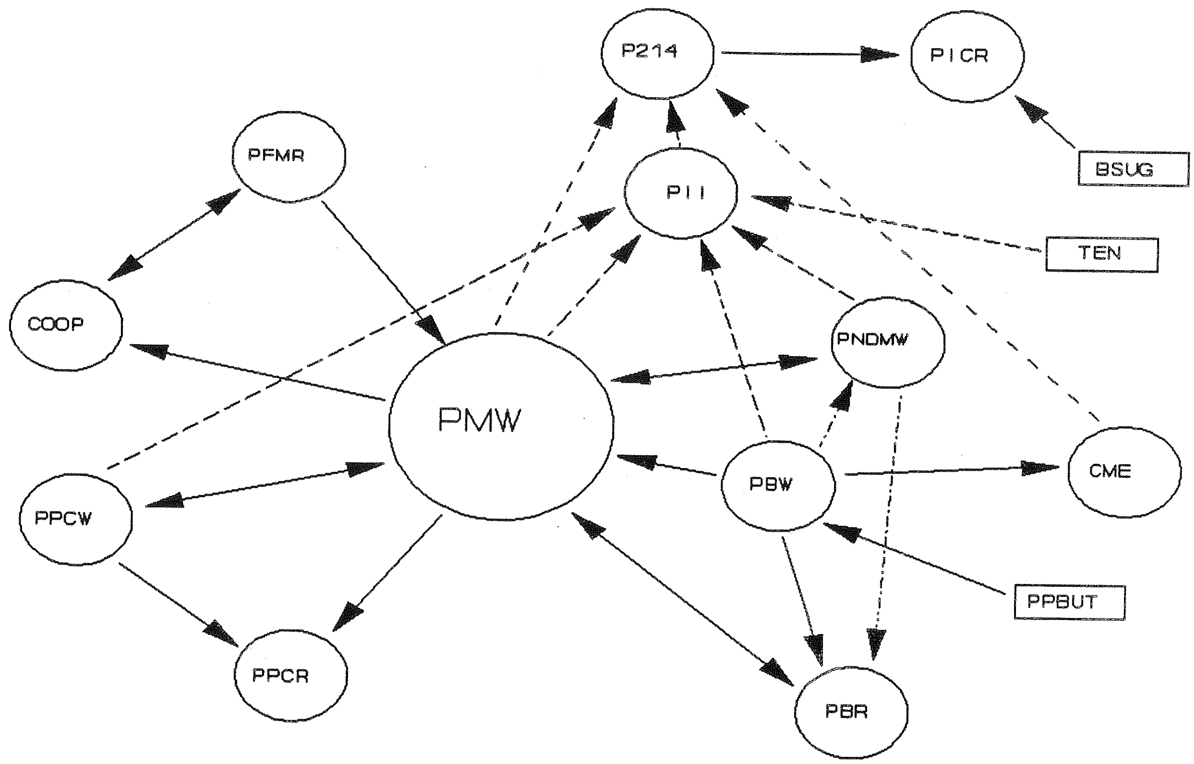

Figure 3
System of Dairy Prices for Transmission Model

Especially in the late 1980s during periods of sharp drops in the farm price, many industry people came to believe that retail dairy product prices responded differently to increasing prices when compared to decreasing prices at lower market levels. Research results by Kinnucan and Forker (1987) and Novakovic (1991) support this concept of asymmetric price responses. Following the approach of Houck (1977), adapted from Wolffram (1969), an asymmetric formulation was used to allow for these different dependent price responses to increasing and decreasing segments of the independent price(s). Asymmetry of prices was tested for in all lags of the independent variables.

These behavioral price equations also included marketing costs and binary variables. Marketing costs were included so that the relationship between the price levels would be estimated net of other significant exogenous variables (Hall et al (1982)). These costs account for the labor, packaging, and fuel portions of the margin between the farm and retail price. A binary (dummy) variable was included to allow for different pricing responses or patterns in the 1988-91 period from the earlier time. Nested F-tests were calculated to determine which specification best fit the equation: both slope and intercept dummy variable; slope dummy variable only; intercept dummy variable only; or neither type of dummy variable.

Houck's method is used to formulate price transmission processes and to test whether asymmetry exists. Current endogenous variables (determined within the system) are expressed as deviations from their initial values. When included on the right-hand side of the particular equation, these endogenous variables, along with the lagged endogenous (predetermined) variables are segmented into cumulative increasing and decreasing marginal variables. By separating each variable, the hypothesis of symmetric price transmission (no statistically significant difference between the two coefficients) can be tested. Marketing cost variables are entered as deviations from their initial values. The trend term measures the behavior of the appropriate price spread, or difference between the prices, over time (Ward). When the trend term is significant and positive, the spread has increased over the sample period. When significant and negative, the spread has decreased over the sample period.

As an example, the generalized forms of the estimated equations for the retail and wholesale prices of processed cheese (**PPCR** and **PPCW**) are presented. The retail price of processed cheese is expressed as a function of both the farm (M-W) and the wholesale prices of processed cheese. Also included are the marketing variables **RW**, **FUEL**, and **PKG**, which represent retail wage rates, fuel, and packaging costs (i.e., retailing, distributing, and processing costs). The general form of this relationship is:

$$PPCR = f_1(PMW,\ PPCW,\ RW,\ FUEL,\ PKG,\ \mu_1)\,. \tag{1}$$

The wholesale price of processed cheese is expressed as a function of the farm price (M-W price) and the marketing variables **PWCHEZ**, **PKG**, and **FUEL**, which represent wage rates in cheese plants, packaging, and fuel. The general form of this equation is:

$$PPCW = f_2(PMW,\ PWCHEZ,\ FUEL,\ PKG,\ \mu_2)\,. \tag{2}$$

The generalized equations may be expressed in empirical form with binary (dummy) variables and lags included, and with the price variables separated into cumulative marginal increases and decreases, as specified by Houck. The wholesale processed cheese price, for example, is separated into the variables SUMPPCW and SUMNPCW, where the former is the increasing (positive) and the latter is the decreasing (negative) wholesale processed cheese price. To allow for different price responses in the 1988-91 period, SUMPPCW and SUMNPCW are multiplied by the binary variable to yield DPPCW and DNPCW, respectively. These variables (along with the "up" and "down" **PMW** variables) are included in the behavioral equation for **PPCR**, the retail processed cheese price:

$$\begin{aligned} PPCR_t = {} & \gamma_1 SUMPPCW_t + \gamma_2 SUMNPCW_t + \gamma_3 DPPCW_t + \gamma_4 DNPCW_t \\ & + \gamma_5 SUMPPCW1 + \gamma_6 SUMNPCW1 + \gamma_7 DPPCW1 + \gamma_8 DNPCW1 \\ & + \gamma_9 SUMPMW_t + \gamma_{10} SUMNMW_t + \gamma_{11} DPMW_t + \gamma_{12} DNMW_t \\ & + \gamma_{13} SUMPMW1 + \gamma_{14} SUMNMW1 + \gamma_{15} DPMW1 + \gamma_{16} DNMW1 \\ & + \gamma_{17} TREND + \gamma_{18} PPCR_0 \\ & + \gamma_{19} RW_{t-0} + \gamma_{20} FUEL_{t-0} + \gamma_{21} PKG_{t-0} + e_{3t} \end{aligned} \tag{3}$$

Identities are necessary to connect the marginal increasing and decreasing values of **PPCW** and **PMW** to the original **PPCW** and **PMW**. These are calculated as follows:

$$SUMPMW_n = \sum_{i=1}^{n}(PMW_t - PMW_{t-1})_i > 0 \tag{4}$$

$$SUMNMW_n = \sum_{i=1}^{n}(PMW_t - PMW_{t-1})_i < 0 \tag{5}$$

$$SUMPPCW_n = \sum_{i=1}^{n}(PPCW_t - PPCW_{t-1})_i > 0 \tag{6}$$

$$SUMNPCW_n = \sum_{i=1}^{n}(PPCW_t - PPCW_{t-1})_i < 0 \tag{7}$$

Identities 4 and 5 are also used in the behavioral equation for the wholesale processed cheese price (**PPCW**):

$$\begin{aligned} PPCW_t = {} & \delta_1 SUMPMW_t + \delta_2 SUMNMW_t \\ & + \delta_3 SUMPMW1 + \delta_4 SUMNMW1 \\ & + \delta_5 SUMPMW2 + \delta_6 SUMNMW2 \\ & + \delta_7 SUMPMW3 + \delta_8 SUMNMW3 \\ & + \delta_9 TREND + \delta_{10} DTREND + \delta_{11} PPCW_0 \\ & + \delta_{12} PWCHEZ_{t-0} + \delta_{13} FUEL_{t-0} + \delta_{14} PKG_{t-0} + e_{4t} \end{aligned} \tag{8}$$

Table 2 summarizes the cumulative impacts for the 1971-91 and 1988-91 periods (without-dummy and dummy variable impacts, respectively). The general results of the price transmission estimation are:

(1) some but not all price pairs are asymmetric;
(2) no one particular pattern exists for which month's prices are asymmetric (e.g. current month only, one and two month lags);
(3) changes due to price increases are typically passed along more than price decreases;
(4) more of the binary slope variable pairs (increasing and decreasing prices) tend to be asymmetric in comparison to the asymmetric full-sample price variable pairs; and
(5) asymmetry appears to be a long-run phenomena for most prices, as per the different increasing and decreasing cumulative effects.

Several qualifications of the price transmission results exist. They are:

(1) high R^2 and low t-ratios are evident, characteristic of time series price data;
(2) many of the parameter estimates have unexpected negative signs, causing difficulty in interpretation;

Table 2
CUMULATIVE IMPACTS OF PRICE TRANSMISSION ESTIMATION

	1971-91	1988-91
FLUID MILK		
COOP:		
PFMR	0.09	-0.18
NFMR	0.08	0.04
PMW	0.63	0.56
NMW	0.64	-0.08
PFMR:		
PCOOP	3.36	2.80
NCOOP	3.28	-0.03
PROC. CHEESE		
PPCW:		
PMW	9.58	---
NMW	9.67	---
PPCR:		
PPCW	-0.44	-0.24
NPCW	-0.21	0.61
PMW	10.96	0.20
NMW	6.50	-12.85
BUTTER		
PBR:		
PBW	1.06	0.13
NBW	0.66	-0.26
PBV	-3.58	3.64
NBV	3.60	-3.33
NONFAT DRY MILK		
PNDMW:		
PPV	7.86	0.09
NPV	8.81	-0.16

Table 2 (Continued)

	1971-91	1988-91
M-W		
PMW:		
PPCW	0.08	---
NPCW	0.08	---
PBW	0.02	0.01
NBW	0.01	0.02
PNDMW	0.00	0.01
NNDMW	0.03	-0.02
PFMR	0.04	0.06
NFMR	-0.01	-0.01
PBR	-0.01	0.07
NBR	0.02	-0.00
ICE CREAM		
PICR:		
P214	0.41	---
N214	1.46	---
PBSUG	0.30	---
NBSUG	0.05	---

(3) the unexpected signs may be a result of multicollinearity due to the large number of estimated parameters or misspecification in the model (e.g. omitted relevant variables); and

(4) negative coefficients and large standard errors may bias the asymmetry test results.

Regardless of the results, the price transmission model was deemed fit for simulation. Gujarati noted that when the regression analysis' purpose is prediction, multicollinearity may not be considered a serious problem.

Model Simulation and Application

Using the parameter estimates obtained for the dairy price transmission model, within-sample simulation was conducted under the assumption that the M-W price was obtained exogenously. With this modification, two applications of the price transmission model demonstrated uses of the model.

Within-Sample Simulation and Ex Post Forecasting

The modified model was used to simulate the product prices for the estimation period and to forecast prices for 1992 through September 1993 using the actual values for the M-W, lagged endogenous, and exogenous variables. Through this application, the simulating and forecasting accuracy of the equation specifications could be assessed.

The general results of this application are:
(1) the equation specification predictions appear to track the actual prices accurately for the within-sample simulation period (pre-1992);
(2) the turning points or changes in price direction appear to be predicted in the month of change or within one month;
(3) the accuracy differs across products and market levels, from very accurate predictions for class II and wholesale processed cheese prices to fairly poor predictions for retail prices of fluid milk, processed cheese, butter, and ice cream over the *ex post* forecast period;
(4) the model has a tendency to over-predict the actual price in the *ex post* forecast period, January 1992 through September 1993; and
(5) the retail price predictions do not follow the actual prices which fell for butter, processed cheese, and ice cream. These prices are predicted to be increasing for the retail prices of processed cheese and ice cream and slowly falling for the retail butter price.

Stable vs. Volatile M-W Price Environment

Pricing patterns at the wholesale and retail levels may change in response to the degree of movement in the M-W; that is, a stable pricing pattern compared to a volatile pricing pattern may lead to different responses by wholesalers and retailers. In this application, dairy product prices for two time periods were simulated: one period exhibited an extremely stable seasonal pricing pattern in the M-W (December 1981 through November 1983) while the second exhibited extremely volatile M-W prices (December 1988 through November 1990). To illustrate the impact of volatility, the model was simulated using the stable period prices and the volatile period prices adjusted to have the same two-year average for the M-W. Using the actual and adjusted actual M-W and other exogenous prices, the market level prices for the other products were simulated, and the simulated prices for the two periods were compared.

The monthly M-W prices over both periods, in dollars per hundredweight, are illustrated in Figure 4. To eliminate the effect of average price level differences, the two-year average of the 1988-90 M-W is normalized to equal the two-year average of the 1981-83 M-W, and monthly M-W prices are adjusted accordingly. Both periods begin with the December price and end with the November price. The horizontal axis labels of January and June are provided as a guide; for example, the first June label represents the actual and adjusted actual M-W prices for June 1982 and 1989. Price volatility in the M-W appears in the 1988-90 period.

Simulated retail and wholesale processed cheese prices, relative to the M-W, are displayed in Figures 5 and 6, respectively. To facilitate comparisons across variables, the resulting simulated prices for each product are scaled relative to the M-W (with 1.0 equal to the actual M-W price).[1] The scaled results illustrated in Figures 5 and 6 do not show actual price movements; rather they show changes in how a variable moves *relative to* the M-W price. If the given market level price (e.g. PPCW) changes at the same rate and in the same direction as the M-W, a stable relationship between the two would exist (i.e. nearly flat line).

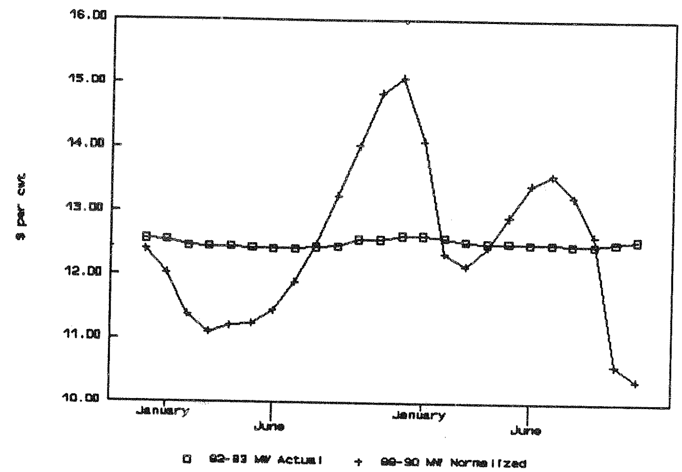

Figure 4
M-W Values for 1981-83 and 1988-90, Normalized to 1981-83 Two-Year Average

If the market level price changes at a rate larger or smaller than the M-W, the movement of the market price relative to the M-W is somewhere between a stable line and a mirror image of the M-W. Examples of volatility in margin between the particular price and the M-W is illustrated in Figures 5 and 6.

Figure 5 is a typical example of the relationship between most market level prices and the M-W. The margin relationship between the M-W and the simulated market level prices are quite stable in the 1981-83 period. However, in the 1988-90 simulation, these prices do not change at the same rate as the volatile M-W, from which greater fluctuation results in the margin relationships. Margin variation is similar (though not identical) across all sectors (generally ranging from about 0.75 to 1.30) with the exception of the wholesale processed cheese price. This indicates that most product prices behave similarly under both stable and volatile M-W price patterns. That is, the monthly price spreads are stable when the M-W is stable and volatile when the M-W is volatile.

The wholesale processed cheese price, shown in Figure 6, does deviate from the typical pattern. Here the relationship between the two prices is stable under both periods

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[1] The scaling factor is: average M-W for the 1981-83 period/average price of product X (e.g. COOP, PBW) for either 1981-83 or 1988-90.

To scale the monthly price *t* where the M-W = 1.0:

$$\frac{\text{Price for } X_t \cdot \text{Scaling factor}}{PMW_t}$$

of simulation, which implies that wholesale cheese prices are just as volatile as the M-W price. This is consistent with the widely held and empirically validated belief that, since the early 1980s, the M-W price closely follows the cheese price.

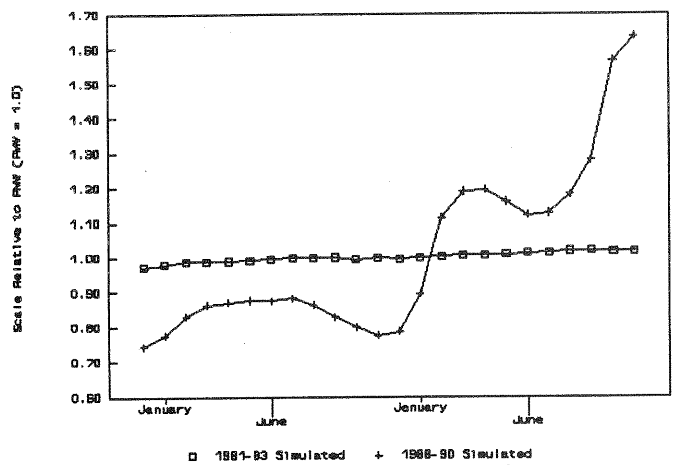

Figure 5
Simulated PPCR Values, Relative to PMW

The general results of the model simulation are:

(1) with one exception, all wholesale and retail market prices show similar margin relationships to the M-W;

(2) for the period in which the M-W is stable, the margin relationship is stable relative to the M-W; neither price changes much compared to the other;

(3) a volatile margin relationship between the M-W and the other prices is apparent when the M-W is unstable (margins are narrowed (widened) when the M-W increases (decreases)); in other words, wholesale and retail prices tend to show less monthly price volatility;

(4) the exception is the wholesale processed cheese price, which maintains a quite stable relationship to the M-W in both the stable and volatile M-W price scenarios; in other words, it varies similarly to the M-W under both stable and volatile regimes;

(5) asymmetric responses result in different average wholesale and retail prices, even with the same average M-W, in both periods;

(6) slightly affected prices (one percent difference

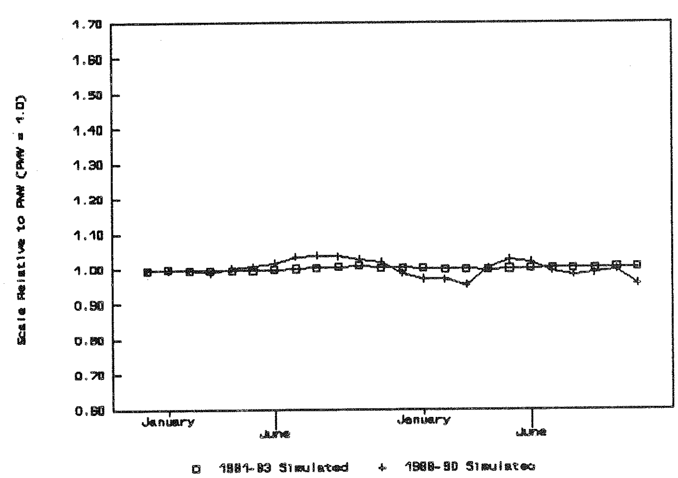

Figure 6
Simulated PPCW Values, Relative to PMW

or less) are observed in wholesale levels of processed cheese and butter, and retail ice cream;

(7) prices that average significantly higher (up to 15 percent more) represent farm levels of fluid milk, ice cream (both class II milk and class II cream), and butter, and retail levels of fluid milk, processed cheese, and butter; and

(8) significantly lower averages are observed for the farm and wholesale prices of nonfat dry milk.

For most sectors, the average price for the volatile price period is greater than for the stable price period, although the relative magnitudes range from small to very large. This affirms the implication of asymmetry, i.e., that processors or retailers react differently to volatile prices than they do to stable prices. The behavioral logic may be that prices are raised to guard against price risk from the fluctuating Minnesota-Wisconsin price. Differences exist within product sectors regarding the price reaction at the market levels. For example, the average cooperative class I and retail fluid milk price each are seven percent higher under the volatile price simulation compared to the stable price scenario; the retailer appears to pass on only the increase in cost. In contrast, the average wholesale processed cheese price increases less than one percent from the stable to the volatile price simulation, but the average retail processed cheese price increases fifteen percent. In this example, wholesalers and retailers respond differently to stable and volatile pricing patterns.

Simulation allows a simplified view of the interaction between dairy prices across market levels and across products. It also enables a researcher to examine the effects of a price change (e.g. in the M-W) on other dairy product prices. In the application above, the average M-W was equalized for two extreme periods and the dairy market prices were simulated. This application of the price transmission model may be used to approach the question, "What is the cost of instability?" within the dairy industry on its participants at the various market levels: consumers, retailers, processors, handlers, and farmers.

Certainly, business decisions of farmers, processors, wholesalers, and retailers are more risky in an unstable price environment because the duration of the volatile period and the magnitude of the price changes are not known. Price uncertainty may make producers more unwilling to invest in their business, or make lenders unwilling to make loans because of the risks involved (Tomek and Robinson). Consumers would also like to have stable prices for their food, but according to the simulation results, they may pay a higher average price depending on the dairy product (e.g. higher for processed cheese but not substantially higher for butter). Likely the farm price fluctuations will be smoothed out by the retailers.

Without including quantities in this model, any quantity response that may occur as a result of price changes (i.e. supply or demand changes) is not expressly taken into consideration. Hence, it is difficult to identify and assess the entire impact on these groups. With quantities, it would be possible to calculate the economic gain or loss (i.e. surplus or loss) of consumers, producers, and the government under different policies, such as a free market (implying more volatile prices) compared to a regulated market (implying more stable prices).

Table 3
VARIABLE DEFINITIONS, PRICE TRANSMISSION MODEL*

FARM PRICES:	
Fluid Milk	
COOP	Announced class I cooperative price at 3.5% butterfat, $/cwt
Processed Cheese, Butter, Nonfat Dry Milk	
PMW	Minnesota-Wisconsin price at 3.5% butterfat, $/cwt
Ice Cream	
P214	Class II price adjusted to 14% butterfat, $/cwt
WHOLESALE PRICES:	
Processed Cheese	
PPCW	National Cheese Exchange price of barrel cheese, cents/lb
Butter	
PBW	Chicago (WSP) wholesale butter price, grade A, cents/lb
CME	Chicago Mercantile Exchange butter price, grade A, cents/lb
Nonfat Dry Milk	
PNDMW	Central States, extra grade nonfat dry milk price, cents/lb
Beet Sugar	
BSUG	U.S. wholesale refined, Midwest market f.o.b. price, cents/lb
RETAIL PRICES:	
Fluid Milk	
PFMR	U.S. retail price of whole fluid milk, cents/half gallon
Processed Cheese	
PPCR	U.S. retail price of American processed cheese, cents/lb
Butter	
PBR	U.S. retail price of grade AA salted stick butter, cents/lb
Ice Cream	
PICR	U.S. retail price of ice cream, cents/half gallon
GOVERNMENT PRICE:	
Purchase Price	
PPBUT	U.S. grade A or higher butter, cents/lb
MARKETING COSTS:	
Wage Rates	
RW	Food Stores, nonsupervisory-worker average earnings, $/hour (SIC 54)
PWCHEZ	Manufacturing - Cheese, Natural and Processed, production-worker average earnings, $/hour (SIC 2022)
Packaging and Fuel	
PKG	Converted paper and paperboard products index, 1982=100 (WPU0915)
FUEL	Fuels and related products and power index, 1982=100 (WPU05)

* Sources of data are listed in DATA SOURCES

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