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GOVERNMENT INFLUENCE ON THE SUPPLY OF COMMERCIAL INVENTORIES OF AMERICAN CHEESE

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PREFACE

Recent years have seen unprecedented price volatility in market prices for American cheese. Concurrently, the Federal government was successful in reducing its purchases of cheese under the Dairy Price Support Program. The market for commercial American cheese inventories was analyzed and results indicate that desired supplies of cheese inventories do respond to market signals.

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THE PROBLEM

The years 1988 through 1990 saw dramatic events in the markets for manufactured dairy products, of which American cheese is a major component. Wholesale prices for American cheese as well as farm-level prices for milk experienced some of the most drastic swings in recent history (figures 1 and 2). Concurrently, government stocks of American cheese experienced unprecedented declines from their record high levels of the middle 1980s (figure 3). Many market participants found that such historically uncharacteristic market conditions created difficult operating environments, especially with respect to the management of inventories:

> *Last year Agri-Mark management had to make decisions on production and inventories not normally made in our business; whether to sell or hold inventories became the major question.* (Agri-Mark)

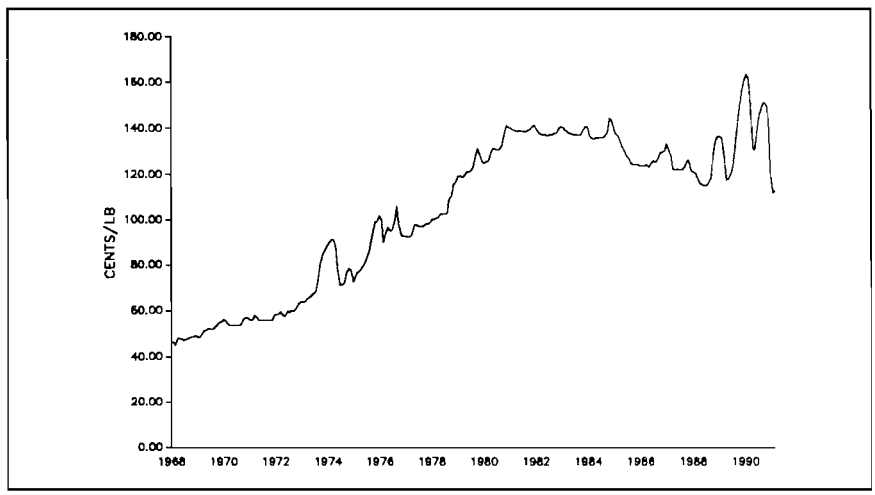

Figure 1. Average Price, Cheddar Cheese, fob Wisconsin Assembly Points, 40 lb. Blocks

A perception exists that market participants who normally provide the commercial inventories of cheese have failed, both recently and during a similar period in 1973-1975, to respond to market conditions, thereby contributing to relatively volatile prices.

> *Although many market swings cannot be predicted accurately, part of the inadequacy of American cheese stocks in each of the last 3 years was related to the industry's failure to adjust its stocking patterns to market signals.* (USDA)

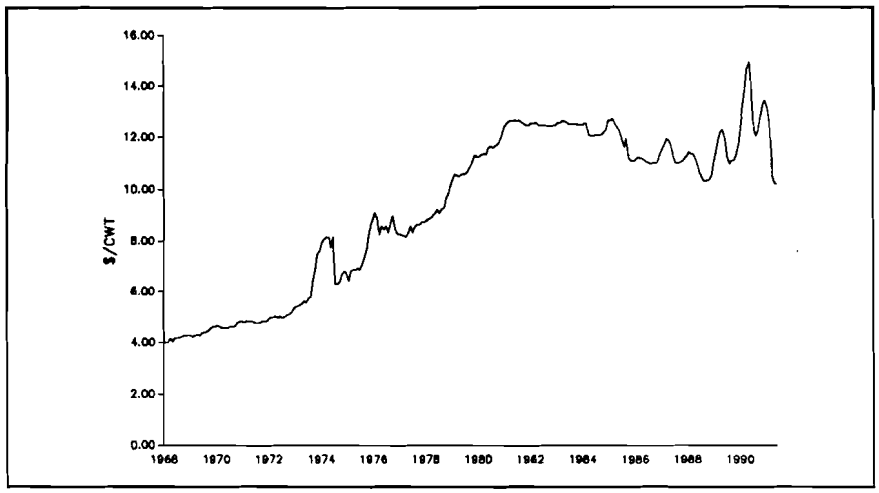

Figure 2. Minnesota-Wisconsin Price for 3.5% Butterfat Milk

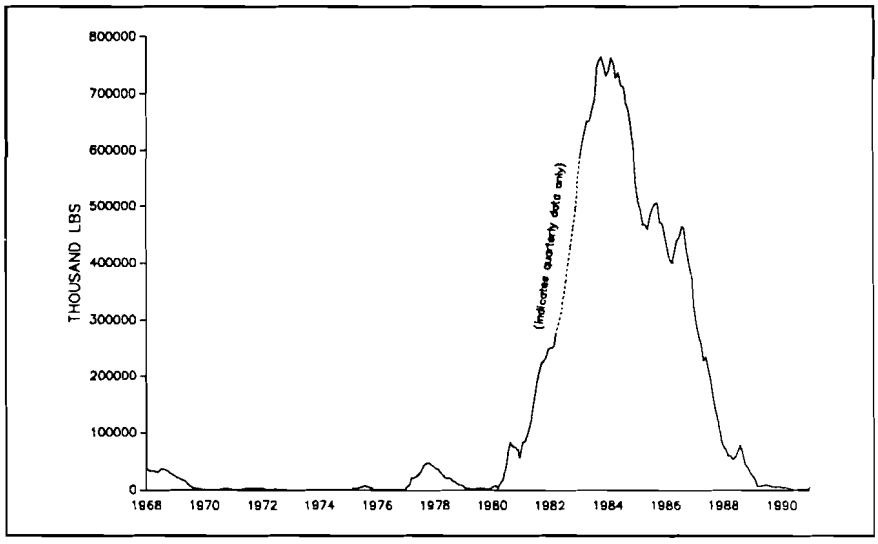

Figure 3. Government-Owned Natural American Cheese

More generally, it is a commonly expressed opinion by many dairy industry analysts that the existence of large inventories of government-owned, storable dairy products reduces the incentives for private interests to hold their own stocks.

> *During 1982—87, commercial American cheese stocks declined fairly steadily, reflecting the profitability of minimizing stocks when a surplus is constant. Under these conditions, the role of stocks can be handled more efficiently by varying the flow of cheese sold to the government.* (USDA)

A logical extention of this opinion is that future reductions in Commodity Credit Corporation (CCC) dairy support activities, and accompanying reductions in government stocks of dairy products, may result in very unstable market conditions. This follows from

the belief that private interests have had incentives to hold less stocks during periods of time when the government held substantial product inventories.

This paper utilizes elements of well-known theories of inventory supply to examine the commercial inventory-holding behavior for American cheese. It provides quantitative estimates, based on historical data, of the aggregated response of dairy stocks managers to storage incentives.

THE GOVERNMENT ROLE

Since its inception, under the Agricultural Adjustment Act of 1933, the Federal Dairy Price Support Program (DPSP) has influenced the markets for some storable dairy products through periodic government purchases of these products. The Agricultural Act of 1949 brought some legislative permanence to the DPSP, and since that time the basic method for implementing the DPSP has continued to hinge on federal purchases of dairy products.

After a support price for milk has been established, the Secretary of Agriculture announces purchase prices for American cheese, butter, and nonfat dry milk. The U.S. Department of Agriculture (USDA), operating through the CCC, represents a perfectly elastic and virtually unlimited demand for these products in wholesale markets. Some government stocks acquired under the DPSP are returned to commercial channels for restricted or unrestricted uses. Unrestricted sales occur when a buyer purchases USDA stocks at prices which are established above the acquisition cost. Recently, simple percentages have been employed to determine the sell-back price. During most of the existence of the DSPS, price floors, the purchase prices, have been far more important than price ceilings, the sell-back prices. There has been only one year since 1949 that the USDA sold more stocks than it acquired.

INVENTORY MANAGEMENT MODELS

The classical theory of "supply of storage" (Brennan, Labys, Working) is based on the premise that owners of commercial stocks will adjust their inventory levels so as to equate the marginal returns from owning stocks with the associated marginal costs. Marginal returns from storage can be partitioned into three categories: speculative, precautionary, and transactions returns (Labys). Speculative returns—appreciation in the value of stocks—result from increases in product prices over the period of time during which stocks are held. Suppliers of stock-holding activity adjust their holdings directly with anticipated changes in price appreciation. These anticipated price changes are referred to as the "price of storage."

Historical evidence indicates that stocks are held even in the face of expected price depreciation (inverse carrying charges), indicating the presence of other forms of returns to storage. These other returns are often described as "precautionary" and "transactions" returns. Precautionary returns result from the ability of owners of stocks, as inputs, to cushion subsequent processing activities from frequent changes in input prices. By owning inventories of raw materials or final products, a manufacturer could reduce the frequency of adjustments

in finished product prices necessitated by changes in raw product prices. Transactions returns result from the advantage of being able to meet orders and satisfy customers in a timely manner without changing production schedules or incurring production delays. There have been empirical applications of this approach to agricultural commodities (Brennan, Lowry et al.).

An alternative approach to inventory behavior is the "production smoothing model" (Binder). Under conditions of convex production costs or nonzero costs for production schedule changes, demand which varies through time will provide incentives for firms to adjust their inventories while smoothing production relative to sales. Miller recently found some evidence that data for condensed and evaporated milk markets were consistent with production smoothing.

Literature in the fields of operations research, industrial organization, and business operations describe the transactions motive for holding inventory as an "Economic Order Quantity" (EOQ) problem (Baumol, Hillier & Lieberman, Levin & Kirkpatrick, Phillips, Ravindran, and Solberg). In its simplest form, the problem is to find the optimal quantity to be ordered during an order cycle. In minimizing the cost per order cycle, it can be assumed, for simplicity, that all order sizes are equal and that an ordering charge is incurred each time an order is placed. There is also a constant level of sales per unit of time and a constant unit storage cost. Replenishment is assumed to occur instantaneously.

Under these restrictive assumptions, the problem is to minimize storage and ordering cost per unit of time as follows:

$$\text{min.} \quad TC = \left(A \cdot \frac{D}{EOQ}\right) + \left(\frac{EOQ}{2} \cdot H\right)$$

where TC = total storage and ordering costs,
A = ordering charge,
D = sales,
EOQ = economic order quantity
and H = storage cost.

At optimality, $EOQ = \sqrt{2AD/H}$. This is variously known as the "EOQ" formula, the "Wilson-Harris" formula, the "economic lot size" rule, or the "square root law." Many variants to the above determination have been specified, relaxing the restrictive assumptions. Most result with optimal transactions inventories as non-linear functions of sales.

Each of the above models uses a single-equation approach for the supply of or demand for storage activities. An integrated approach is to consider the market for inventories in a more traditional fashion whereby supply and demand considerations interact to simultaneously determine a market equilibrium price and inventory level (Telser). The following empirical analysis uses a simple, two-equation approach to modelling the inventories market for American cheese. The specification of each side of the market is based on the previously cited literature.

THE EMPIRICAL MODEL

Market level supply and demand functions for American cheese inventories are hypothesized to jointly determine the price and the quantity of inventories at any point in time. For the supply of inventories, it is postulated that:

$$(1) \qquad COMMSTKS_t = \alpha_0 + \alpha_1 CHEESEPRICE_t + \alpha_2 CCCPRICE_t + \alpha_3 INTERESTRATE_t + \alpha_4 GVTSTKS_t$$

where

$COMMSTKS_t$ = monthly ending commercial inventories of American cheese, (1,000 lbs.)

$CHEESEPRICE_t$ = monthly average real price, cheddar cheese f.o.b. Wisconsin assembly points, 40 lb. blocks (cents/lb.)

$CCCPRICE_t$ = real CCC announced purchase price, cheese in 40 lb. blocks (cents/lb.)

$INTERESTRATE_t$ = annualized real interest rate on 3-month treasury bills

and

$GVTSTKS_t$ = monthly ending inventories of government-owned American cheese.

For the demand for American cheese inventories it is postulated that:

$$(2) \qquad COMMSTKS_t = \beta_0 + \beta_1 CHEESEPRICE_t + \beta_2 CCCPRICE_t + \beta_3 \sqrt{DAILYPROD_t},$$

where

$DAILYPROD_t$ = daily average cheese production for month t.

For the inventory supply equation (1), the current price of cheese and the current CCC purchase price determine the price of storage. The CCC purchase price represents a floor below which market prices are unlikely to persist. While the DPSP has not operated as a pure price stabilization program, market prices have tended to follow support prices, though far from perfectly. Instead of the current period difference in price between two futures contracts with different dates, the price difference between current cheese prices and current CCC purchase prices represent the speculative prospects. The current period cheese price is endogenous, while the CCC purchase price is exogenous. The real interest rate (Helmers et al.) on 90-day treasury bills represents the opportunity costs of inventory assets. Government stocks of American cheese are included to empirically test the widely-held belief that the actual levels of government-owned inventories influence commercial inventories.

For the inventory demand equation (2), the current price of cheese and the current CCC purchase price again determine the price of storage. We would expect that changes in either one of these variables, indicating speculative prospects, would influence the quantity of desired inventories on the part of inventory users. Transactions, or pipeline, demands for stocks are hypothesized to be nonlinearly related to average daily cheese production for the current month, as users minimize their EOQ.

EMPIRICAL RESULTS

Using monthly data for the period February 1983 through January 1989, estimates of the structural parameters of equation (1), the identified supply of inventory equation, were obtained using a two-stage least squares procedure (Pindyck & Rubinfeld, p.298). The Hildreth-Lu serial correlation correction procedure was used in stage two to correct for auto-correlated errors (Pindyck & Rubinfeld, p.142). Estimated coefficients and standard errors are reported in Table 1, and summary statistics for the sample data are reported in Table 2.

Table 1. Estimation Results

(1) $COMMSTKS_t$ = 210,838 -2,567 $CHEESEPRICE_t$
(2.32) (-1.86)
+ 3,411 $CCCPRICE_t$ + 1,510 $INTERESTRATE_t$
(2.47) (.28)
+ .053 $GVTSTKS_t$
(1.05)

$R = .75$ $\rho = .75$

Note: Figures in parentheses are t-ratios of the coefficients.

Table 2. Sample Statistics for Data

	COMMSTKS	CHEESEPRICE	CCCPRICE	INTERESTRATE	GVTSTKS
Maximum	391,727	141.34	142.49	6.66	765,543
Minimum	229,178	97.84	95.17	1.23	20,400
Mean	331,332	119.44	117.20	3.77	412,652
Standard Deviation	35,513	12.77	14.20	1.36	246,613
Coefficient of variation (%)	10.72	10.69	12.12	35.97	59.76

Coefficients for the current real price of cheese and the current real CCC purchase price indicate that a narrowing of the difference between market price and the price "floor" is associated with an increase in the supply of storage. Decreases in market prices as well as increases in the CCC purchase price, at given levels of all other independent variables, produce incentives for commercial storage supply interests to provide more inventories.

Results indicate, however, that these responses may not be symmetric. The market price elasticity of inventory supply is 0.9 and the CCC purchase price elasticity of supply is 1.2, calculated at the means. A 1¢ decrease in the market price is estimated to result in a 2,567,000 lb. increase in the desired supply of storage, whereas a 1¢ increase in the CCC purchase price is estimated to result in a 3,411,000 lb. increase. Relatively, a one-standard deviation change in the market price or CCC purchase price implies 0.92 and 1.36 standard deviation changes in desired commercial inventory supply.

Ample evidence exists with respect to efforts by cheesemakers to "protect" the values of inventories during periods of falling prices. (For example, see Miller Publishing Co.) This might reflect the fact that there is much less risk for losses of inventory values, brought about by decreases in market price, when the market price is close to the CCC purchase price. As these prices diverge, the risk of loss increases due to 1) the relatively higher value of inventory, and 2) the increased likelihood that the difference will narrow. Market price increases and CCC purchase price decreases; both increase the potential magnitude and the probability of a subsequent loss in inventory value.

The coefficient on the real rate of interest indicates a positive supply response to increases in the interest rate. While this is an unexpected result, the t–statistic for this coefficient indicates that it is highly unreliable. During the period of estimation, 1983-1988, real interest rates were much less variable than during the previous fifteen years. A higher and less variable level may not provide enough variation to determine the true relationship between desired stocks and real interest rates.

The coefficient on government stocks is positive, but statistically unreliable. For the sample period, one during which government stocks had tremendous variability, no statistically reliable relationship between government and commercial stocks was indicated. The relationship which was found actually indicated a positive response instead of the commonly assumed negative response.

CONCLUDING COMMENTS

Using a simultaneous equation approach and data for the period February 1983–January 1988, the market for commercial American cheese inventories was analyzed. Results indicate that the suppliers of American cheese inventories respond to market signals in the form of price. Both the market price and the CCC purchase price have influence on the desired supply of commercial inventories. More stocks are offered at narrower differences between market and government prices than at wider ones. Real rates of interest had no statistically reliable relationship to stocks. The sample relationship between government and commercial stocks was also unreliable, but could possibly be positive.

During a period when government inventory activity had a high level of variability, the statistical evidence is weak with regard to the impact of levels of government stocks on commercial inventory behavior. CCC purchase prices, on the other hand, appear to have a statistically and qualitatively large influence on desired supply levels of commercial

inventories. As CCC purchase prices fall, relative to market prices, commercial interests adjust desired stocks downward.

Historical evidence indicates that the aggregate supply of American cheese inventories does indeed respond to current market signals and in a way which could contribute to stable market prices. At times of relatively high market prices, the desired levels of inventories are reduced. When market prices are closer to the CCC purchase price, cheese inventory suppliers have larger levels of desired cheese inventories.

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