An Econometric Model for Forecasting the Manufacturing Grade Price of Milk in U.S. Markets

by

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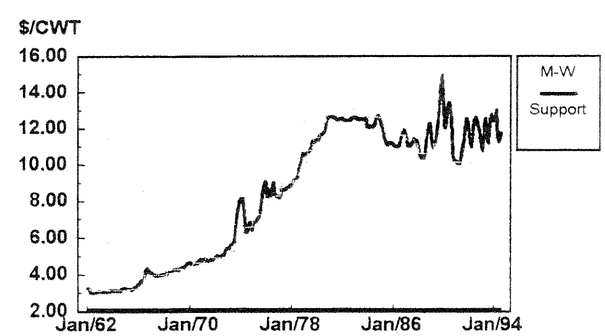
The object of this paper is to develop a forecasting tool that will accurately predict the M-W price series. The model reflects the Secretary's final decision for the new M-W estimate, which consists of the base month M-W lagged one month, plus an update price formula. The statistical model in this report estimates the base month M-W as a function of dairy commodity prices. The latter are used as a proxy for the gross wholesale value of milk used in cheese and butter/nonfat dry milk plants in Minnesota and Wisconsin. The statistical results indicate the model is accurate.

Introduction

Milk prices have become much more volatile in recent years due to the reduction in the support price for manufacturing grade milk. In the past, the government implicitly set the price of milk at the farm level through the price support program and federal orders. The price support program placed a floor beneath the manufacturing grade price of milk (called the M-W). Over the period 1960-1986, for example, the support price for milk was set above the market-clearing price for manufacturing grade milk. As a result, the government acquired surplus dairy commodities (cheese, nonfat dry milk, and butter) and the support price set the M-W (see Figure 1). The support price also set the farm gate price for milk since the M-W price series forms the basis for milk pricing under federal orders.

The M-W today is no longer related to the support price for milk since the latter has declined from a high of $13.49 in October, 1981, to $10.10 today. In fact, the M-W hasn't been at the level of support since 1990. As a result, the M-W is much more difficult to forecast due to it's increased volatility. But having an accurate forecast of the M-W is crucial to both farmers and processors due to its importance in determining farm gate prices under federal orders and to its impact on the cost of procuring milk.

Figure 1. M-W and the Support Price for Milk



The object of this paper is to develop a forecasting tool that will accurately predict the M-W price series. This paper will first describe the M-W and then layout the forecasting model.

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Background to the M-W

The Minnesota-Wisconsin (M-W) price series is a statistically estimated price for manufacturing grade milk. It is estimated based on competitive market conditions in the unregulated market for Grade B[2] milk in Minnesota and Wisconsin, where about half of the nation's supply of Grade B milk is produced. The M-W reflects a competitive free market price for surplus milk and serves as an explicit link between Grade B and surplus Grade A milk prices. This link is due to the fact that manufactured dairy products compete on a national market and can be produced from either Grade B milk or surplus Grade A milk.

The M-W is considered an "estimate" since it is based in part on a survey (called the M-W sample) of plant prices during the first two weeks of the month. For example, the August M-W would be released by the USDA on September 5 and would be based on the M-W survey of prices paid during the first two weeks of August. The "base price" of manufacturing grade milk would be reported the following month, after a second and more extensive full-month survey (called the milk price/dairy products survey) is conducted. In our example, the August base price would be released October 5. USDA strives each month to estimate the M-W to be as close as possible to the base price which is released the following month.

The M-W price is computed by the National Agricultural Statistics Service (NASS) on or before the fifth of each month and represents manufacturing grade milk delivered f.o.b. plant or receiving station, whichever is the customary point for determining the milk price to producers (USDA 1992). It is estimated before hauling costs, producer assessments and checkoff's are deducted, and includes quantity, quality, protein, and other premiums paid to producers. The data used to estimate the M-W is for Grade B milk only and does not reflect Grade A milk diverted to manufacturing uses.

The Minnesota and Wisconsin Agricultural Statistics Offices, in cooperation with NASS, mails out the milk price/dairy products questionnaire to about 130 Grade B plants in Wisconsin and about 73 plants in Minnesota by the 15th of each month. The milk in these plants represents approximately 80 percent of all manufacturing-grade milk sold in these two States. Part of the information requested is actual data on pay prices for milk (which would reflect premiums), as well as levels of protein, butterfat, and solids-not-fat. Information derived from this survey is used to estimate the "true" or base price of manufacturing grade milk.

The Minnesota and Wisconsin Agricultural Statistics Offices also mails out the M-W sample to about 18 plants in Minnesota and 43 plants in Wisconsin also by the 15th of each month. These plants account for about 37 percent of the manufacturing grade milk sold in these two states. This survey is due on the 4th of the following month and covers prices paid during the

[2]There are two grades of milk in the U.S.: Grade A and Grade B milk. Grade A milk represents about 96 percent of the U.S. milk supply. It is produced under more sanitary conditions than Grade B milk. Grade A milk can be used for bottling purposes as well as manufacturing purposes. Grade B milk, on the other hand, can only be used for manufacturing purposes.

first two weeks of the preceding month. A pay price is computed from this survey each month and is called the "basic price." It is reported by NASS at 3.5 percent butterfat and reflects no premiums. The plants in the survey also report their estimate of milk pay prices for the second half of the month. So, by the 4th of September, NASS offices would receive the plant surveys from the M-W sample and would estimate a basic pay price based on survey prices for the first half of August. In addition, they would also have estimates from these plants of pay prices for the second half of August.

The reported M-W estimate then is calculated by NASS after taking into consideration a number of factors, such as 1) prices paid in the M-W sample and last month's base price, 2) the historical relationship between these two prices, 3) the forecast of milk pay prices for the second half of the current month as reported by plants in the smaller M-W sample, 4) changes in monthly prices of manufactured dairy products during the current month, 5) historical trends in milk prices, butterfat test, and protein test, and 6) overall supply-demand conditions. A clear-cut formula cannot be used in the calculation of the M-W estimate since the objective of NASS is to develop an estimate of the M-W that tracks as close as possible to the base price reported in the following month.

Plants surveyed in Minnesota and Wisconsin are classified into three major product groups. These groups are cheese, butter and its by-products, and varied products. The latter refers to plants that do not make dairy products, or do not fit clearly into a butter or cheese classification. In 1993, 68 percent of all plants in Minnesota produced cheese, 21 percent butter and related products, and 11 percent varied products. In Wisconsin that same year, 87 percent of all plants produced cheese, 1 percent produced butter and related products, and 12 percent produced varied products. The point here is that the majority of plants surveyed in Minnesota and Wisconsin (about 95 percent) make cheese. Therefore, cheese prices are likely to have a far greater impact on the M-W price series than other dairy products.

Once the M-W estimate is computed, it is converted to a 3.5 percent butterfat basis. This is accomplished using an average butterfat test for both Minnesota and Wisconsin as computed from the monthly M-W survey, and a butterfat differential computed each month by NASS. The butterfat differential is computed on a cents per point basis and reflects the value of butterfat in milk. It is equal to the monthly average wholesale price per pound of Grade A butter on the Chicago Mercantile Exchange times .138 minus 0.0028 times the current M-W price at test.

The M-W price at 3.5 percent butterfat is derived from the M-W at test as follows:

equation 1 $$\text{M-W}_{3.5\%bf} = \text{M-W}_{test} - (\text{BFT} - 3.5)*0.1*\text{BFD}$$

where:

$\text{M-W}_{3.5\%bf}$	=	the M-W price at 3.5 percent butterfat, and
M-W_{test}	=	the M-W estimate at test.
BFT	=	butterfat test, %
BFD	=	butter fat differential, cents per tenth of a point

The M-W Replacement

The USDA announced in June 1990 that it was conducting an extensive study of alternative pricing mechanisms that could replace the current M-W price series (USDA 1991). USDA's concern was that the M-W series as computed then would no longer be statistically reliable since Grade B milk marketings had declined from 33 percent of total U.S. marketings in 1960 to just 8 percent in 1990. A public hearing was held June 15-19, 1992, where industry proposals were considered.

These proposals are categorized into four areas: 1) product price formulas 2) competitive price series 3) cost of production formulas and 4) price support level (USDA, Sept. 1991). Out of the four, only the competitive price series met the provisions set forth by the Agricultural Marketing Agreement Act of 1937 (the Act). The base month M-W price plus an update formula proposal and the A/B price series proposal, both from the competitive price series, met the provisions of the Act.

An M-W replacement was recommended by the Secretary in a final recommended decision on January, 1995. The USDA chose the base month M-W price with the update formula for two reasons. First, the A/B price series would have resulted in a upward bias of pricing milk due to the inclusion of the higher priced Grade A milk. Second, the update formula provides an accurate indication of monthly changes in supply and demand factors effecting the market for manufactured dairy products. This recommendation would maintain the full-month milk price/dairy products survey in Minnesota and Wisconsin that was used to estimate the base price, but would replace the two-week M-W sample survey with a butter/nonfat dry milk/cheese formula that would serve to update the base price (USDA 1994). Such a change will result in an M-W estimate that is more responsive to changes in dairy commodity prices.

The M-W replacement estimate in the Secretary's final decision will be estimated as follows:

equation 2 $$M\text{-}W(t)_{test} = M\text{-}W(t-1)_{base} + WCGVM(t)$$

where:

Mw_{base} = the base month M-W at test, \$/cwt

WCGVM = weighted change in the gross value of milk, \$/cwt

t = month.

Update Formula

The gross value change in the value of milk from the preceding month will be used to update the base month price in the M-W estimate. This change is estimated from the gross value of milk used to manufacture cheese, butter and nonfat dry milk as follows:

Step 1: Determine the gross value of milk used to manufacture cheddar cheese and butter/nonfat dry milk:

equation 3	GVMC	=	(9.87 * NCE) + (.238 * BUTA)
equation 4	GVMBN	=	(4.27 * BUTAA) + (8.07 * NFDM) + (.42 * DBM)

where:

GVMC	=	gross value of milk used for cheese production
NCE	=	weighted monthly average prices for 40lb block cheese on the National Cheese Exchange, $/lb
BUTA	=	weighted monthly average price for Grade A Butter on the Chicago Mercantile Exchange, $/lb
GVMBN	=	gross value of milk used for butter/nonfat dry milk production
BUTAA	=	weighted monthly average price for Grade AA Butter on the Chicago Mercantile Exchange, $/lb
NFDM	=	weighted monthly average price for nonfat dry milk, high/low average for Western States, $/lb
DBM	=	weighted monthly average price for dry buttermilk, high/low average for the Western States, $/lb

The gross value of milk is estimated based on average product yields and wholesale output prices for a cheese plant and a butter/nonfat dry milk plant. Note that equation 3 reflects the value of whey butter, which is a byproduct of cheese production. Likewise, equation 4 reflects the value of buttermilk which is also a byproduct of butter and nonfat dry milk production.

Step 2: Calculate the change in the gross value of milk for cheese and for butter/nonfat dry milk from the proceeding month:

equation 5	CGVMC	=	GVMC(t) - GVMC(t-1)
equation 6	CGVMBN	=	GVMBN(t) - GVMBN(t-1)

Step 3: Compute a factor to weight the change in the gross value of milk for cheese and for butter/nonfat dry milk to be used as follows:

equation 7	WCGVM	=	β*CGVMC + (1 - β)*CGVMBN

where β is the weighting factor that is computed as follows:

equation 8	β	=	MEC / TME
equation 9	TME	=	(AMCP / 9.87) + (NFDMP / 8.07)
equation 10	MEC	=	AMCP / 9.87

where:

MEC	=	Milk equivalent of cheese production in Minnesota and Wisconsin for the most recent preceding period
TME	=	Total milk equivalent for American cheese production and nonfat dry milk production in Minnesota and Wisconsin.
AMCP	=	American cheese production in Minnesota and Wisconsin for the most recent preceding period
NFDMP	=	Nonfat dry milk production in Minnesota and Wisconsin for the most recent preceding period

The weights are derived to approximate the percent of milk used in the production of cheese or butter and nonfat dry milk. Note that the milk equivalent of nonfat dry milk is used to approximate the volume of milk used in butter/nonfat dry milk plants. That is because the milk equivalent of butter production would overstate the amount of milk used in butter/nonfat dry milk plants since butter is also a byproduct of cheese plants.

The Statistical Model

The new M-W replacement is presented in equation 2 above. A statistical model was estimated in this section to forecast the new M-W and is based on equation 2. This model consists of a statistical model that estimates the base month price, plus the update formula. Both the statistical model of the base month price and the update price formula can be forecasted from projections of commodity prices.

The statistical model for the base month prices is as follows:

equation 11 $EMWB(t) = f(MWVM)$

where:

EMWB	=	estimated M-W base month price at test, \$/cwt
MWVM	=	weighted monthly wholesale value of manufacturing grade milk, \$/cwt

The MWVM is computed from yield factors and wholesale dairy commodity prices to reflect the wholesale value of milk in a cheese and a butter/nonfat dry milk plant as follows:

equation 12 $MWVM = \theta * VMCP + (1-\theta) * VMBP$

equation 13 $VMCP = 10.1 * NCE + .59 * BUTB + 5.8 * DW$

equation 14 $VMBP = 8.13 * NFDM + 4.48 * BUTA + .45 * DBM$

where:

VMCP	=	monthly wholesale value of Grade B milk used in the production of cheese
BUTB	=	weighted monthly average price for Grade B Butter on the Chicago Mercantile Exchange, \$/lb
VMBP	=	monthly wholesale value of Grade B milk used in the production of nonfat

		dry milk and butter
θ	=	a six year average of the percent of Grade B milk used in cheese plants in Minnesota and Wisconsin
DW	=	weighted monthly average price of dry whey, high/low average for Central States, $/lb

We postulated that there is a statistical relationship between our proxy for the wholesale gross value of milk (MWVM) and the M-W base price at test. These two series are graphed below in Figure 2. The MWVM tracks the M-W base month price closely. Notice that our definitions for the wholesale gross value of milk (VMCP and VMBP) used to estimate the statistical model are slightly different than the definitions of GVMC and GVMBN used in the Secretary's final decision.

The coefficients for the statistical model were estimated using the Autoregression Time Series function in the SAS Program. The model estimated the relationship between the base month M-W at test and the wholesale value of milk (MWVM). We used a second-order autoregression due to the presence of autocorrelation between the error terms. A second-order autoregression was used as opposed to a first-order since the latter did not converge during the maximum likelihood estimation procedure.

The statistical results are presented below in Table 1. The output from Table 1 shows that the autoregressive parameter estimates of -1.1314 and .6000 have a significant t-ratio of -11.05 and 4.96, respectively. This confirms that our AR(2) model provides a good fit to the data.

Figure 1: Wholesale Value of Milk vs. Base Month M-W

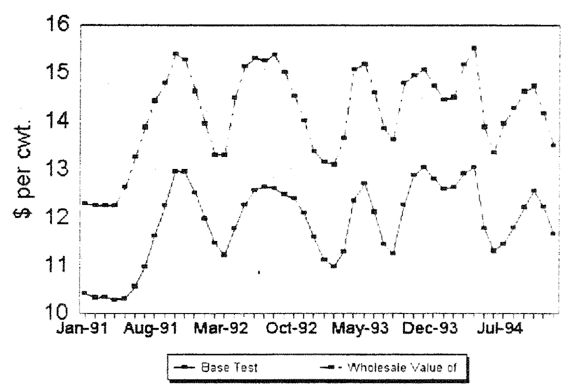

Table 1. Parameter estimates for the M-W Base Price at Test

	Coefficients	t-ratio
Intercept	2.0137	3.13
MWVM	.6973	15.40
A(1)	-1.1314	-11.05
A(2)	.6000	4.96
Total Rsq	.9722	

The final model is therefore written as follows:

equation 14 EMWB(t) = 2.01377651 + .6973972*MWVM(t) + 1.13404925*YHAT(t-1) - .60000063*YHAT(t-2)

where:
YHAT(t) = $MW(t)_{base}$ - (2.0137 + .6973972*MWVM(t)

where MW_{base} is the true M-W base month price. The statistical model provides an estimate of the base month price at test. This should then be corrected to 3.5 % butterfat using equation 1 above.

The base month estimate at 3.5 percent represents the base month price that the National Agricultural Statistics Service estimates each month from their survey data. The model, with an 97% r-squared, is statistically accurate. Table 2 shows the errors between the actual and predicted base month prices after correcting to 3.5 percent butterfat:

Table 2. Actual v. Predicted for the M-W base Month Price Equation

	Predicted	Actual	Error
Sep 94	12.01	12.07	-.06
Oct 94	12.15	12.31	-.16
Nov 94	11.96	11.95	.01
Dec 94	11.45	11.42	.03
Jan 95	11.35	11.43	-.08
Feb 95	11.71	11.74	-.03

Conclusions

The objective of this paper was to estimate a practical forecasting tool to predict the manufacturing grade price of milk used in federal orders. The model reflects the Secretary's final decision for the new M-W estimate, which consists of the base month M-W lagged one month, plus an update price formula. The statistical model in this report estimated the base month M-W as a function of dairy commodity prices. The latter are used as a proxy for the gross wholesale value of milk used in cheese and butter/nonfat dry milk plants in Minnesota and Wisconsin. The statistical results indicate the model is accurate.

The statistical model for the M-W base month price can be used in conjunction with the update formula defined in the Secretary's final decision to forecast the new M-W. This forecasting model, however, is dependent on forecasts of commodity prices for cheese, nonfat dry milk, butter, whey, and production of cheese and nonfat dry milk in Minnesota and Wisconsin.

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