Forecasting Farmers' Response to the Farmer-Owned Reserve Program

by

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During the five years since its inception the Farmer-Owned Reserve (FOR) has become an important component of commodity market structure as well as a major grains policy instrument. Ending FOR stocks of corn and wheat are expected to be 33 and 38 percent, respectively, of production for the 1982/83 crop year and they have been as small as 3 percent of production for corn (1980/81) and 12 percent for wheat (1979/80). The size and variability of the FOR and its obvious influence on price behavior presents a challenge to commodity analysts. Much effort during the last two decades has been devoted to understanding the response of farmers to acreage diversion and set-aside programs in order that we can forecast area planted under a given set of program provisions. It is equally important to model farmers' response to reserve program provisions in order to forecast quantities of grain withheld from the market in the form of reserve stocks.

To date, most models and analysts have treated reserve quantities as exogenous variables. For example, at this conference last year Womack, et al. presented impact multipliers from an annual model which indicated that a 100 million bushel income in FOR stock of corn (wheat) would increase season average price by about \$.15 (\$.26) per bushel. Such information is useful for "what if" questions; but to forecast reserve quantities and

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prices simultaneously, the impact of prices on reserve quantities must also be known.

Our research has focused on identifying the response of corn reserve placements to changes in reserve program provisions, participation eligibility and market conditions. Policy variables were developed to measure the expected return to a reserve contract. These variables explicitly include all of the reserve program provisions. Corn reserve placement models are formulated to include these policy variables, market price, and measures of corn available for placement.

Monthly data is used to estimate model parameters. These estimated equations are used in forecasting grain reserve quantities. We also suggest techniques for using these relationships with commodity and price forecasting models.

Method

The reserve program is by now well known, and we will not dwell upon a lengthy description of its operation. There are two distinct decisions faced by farmers, provided that they are eligible to enter the program:

1. The placement decision. Should grain be placed in the reserve, and how much?
2. The redemption decision. Should grain in the reserve be redeemed when trigger prices are reached, and how much?

We assume that farmers compare the discounted expected costs and benefits deriving from participation to the expected return from alternative uses of the grain.

The factors that are likely to determine the costs and benefits of grain placement are:

<u>Program provisions</u>

E - eligibility criterion

i - interest charged on government loans

N - number of months of interest charged

PL - loan rate

S - storage payments

<u>Market factors</u>

C - storage costs

P* - expected sales price at redemption

r - discount rate

s - expected shrinkage or deterioration

T - expected months of storage before redemption

The factors that are likely to determine the costs and benefits of continuing to hold reserve grain after redemption is permitted are very similar. Storage payments are dropped from the list, since they are discontinued soon after release is announced.

Even with the number of observations provided by monthly observations, this is a long list of potentially important variables. The factors that value alternative uses have yet to be considered. Moreover, in many months during the period either placements or redemptions or both were zero. What is needed to make the estimation problem tractable is a means of combining these factors into fewer summary variables.

Model Specification

Meyers and Jolly have suggested a theoretical model which can be applied in this case. First the problem is simplified by choosing a cash sale price (MKT) as the alternative to which reserve participation is compared. Second, the expected return to participation is expressed as the present value of costs and benefits associated with placing a bushel of grain in the reserve. This present value computation combines most of the program and market factors listed above into a single summary variable (PPV). Third, there is a maximum quantity available for placement (QAP) in any given period.

The expected signs for the placement function are:

$$(1) \qquad QP_t = f(\overset{-}{MKT_t}, \overset{+}{PPV_t}, \overset{+}{QAP_t})$$

Policies which make the reserve more attractive or factors that increase expected sale price will shift the function to the right (more placements). Higher current price means fewer placements. A larger quantity eligible for the reserve increases placements.

The placement function can be derived from a joint probability function of reservation prices and quantities and thus takes the form of a distribution function. A functional form which is both convenient to use and appropriate for this case is the logistic function

$$(2) \qquad QP_t = \frac{QAP_t}{1 + \exp\left[-(\alpha + \beta X_t)\right]}$$

where QP approaches QAP in the limit as $(\alpha + \beta X_t)$ increases. We now define the placement function variables.

Numerous simplifying assumptions are made in defining the independent variables. The purpose is to avoid undue complexity while incorporating all the reserve program provisions in a manner consistent with their expected influence on farmers' decisions.

The present value of a bushel of grain placed in the reserve (PPV) is defined in accordance with Meyers and Jolly. The expression is simplified somewhat by omitting loading costs and the storage subsidy refund which do not contribute significantly to variability of PPV across time. Also the stochastic components, expected sale price and length of storage, are given assumed values.

(3) $$PPV_t = LOAN_t + \sum_{j=1}^{T} \frac{SPMT_t - SCOST_t}{(1 + TBOND_t)^{j-1}} + \frac{(1 - S)*PEXP_t - (1 + I_t *N_t)*LOAN_t}{(1 + TBOND_t)^T}$$

where

I = annual rate of interest on reserve loans

LOAN = loan rate per bushel on reserve loans

N = years of interest charged on reserve loans

PEXP = expected sale price at redemption

S = percent lost due to shrinkage and quality deterioration

SCOST = annual farm storage cost

SPMT = annual storage payment rate

T = expected length of storage

TBOND = interest rate on 3 year treasury bond

The expected sale price is set midway between the release and call levels, and the expected length of storage is set at 2 years.

To approximate the grain available for placement in the reserve (QAP) we make the following assumptions:

1. Only set-aside program participants are eligible for reserve participation,
2. Grain reserve placements reduce availability but reserve redemptions increase availability by substitution with new crop grain.
3. Grain marketing reduces availability

Eligible grain in year s is defined as production (PROD) times the acreage reduction participation rate (PART).

(4) $ELIG_s = PART_s \cdot PROD_s$

The aggregate quantity of grain available at the beginning of each month t in year s is estimated by

(5) $QAP_{st} = (HARV_t - SLD_t)ELIG_s - (1 - SLD_t)(BRS_{st} - BRS_{s1})$

where

$HARV_t$ = proportion of current crop harvested by beginning of month

SLD_t = proportion of corn normally marketed by beginning of month t

BRS_{st} = reserve level at beginning of month t in year s

The first term in equation (5) measures the quantity of eligible grain harvested but not yet marketed at the beginning of month t. The second term measures the quantity of grain removed from (added to) available supplies as result of placements (redemptions) that have occurred since the beginning of the crop year.[1/]

With the variables thus defined, the placement specification is:

$$(6) \qquad QP_t = QAP_t/\{1 + \exp[-(\alpha + \beta MKT_t + \gamma PPV_t)]\} + u_t \qquad \beta < 0,\ \gamma > 0$$

Figure 1 illustrates how this function may behave in a typical year as QAP and prices change through the year.

Empirical Results

Only periods with "direct entry" were included in the estimation period. Also omitted was part of the period in crop year 1980/81 when interest on reserve loans was completely waived. Placement functions were estimated over two periods -- October 1979-November 1980 (Model I) and the same period plus March 1981-September 1982 (Model II). Earlier periods were omitted because direct entry was not permitted, and December 1980-February 1981 was omitted because of the interest-free loan provision.

Initial evaluation of the results indicated the participation rate (PART) may influence behavior in ways other than through the constraint QAP. Thus Models Ib and IIb include an intercept shift variable associated with PART. The negative coefficient on this shift variable moderates the effect of changes in participation, since the effect through the QAP variable is clearly positive. The price and PPV variables are significant in most of

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[1/] Although redeemed old crop grain cannot be placed in new crop reserve, it can replace new crop grain marketed and thus make more new crop grain available.

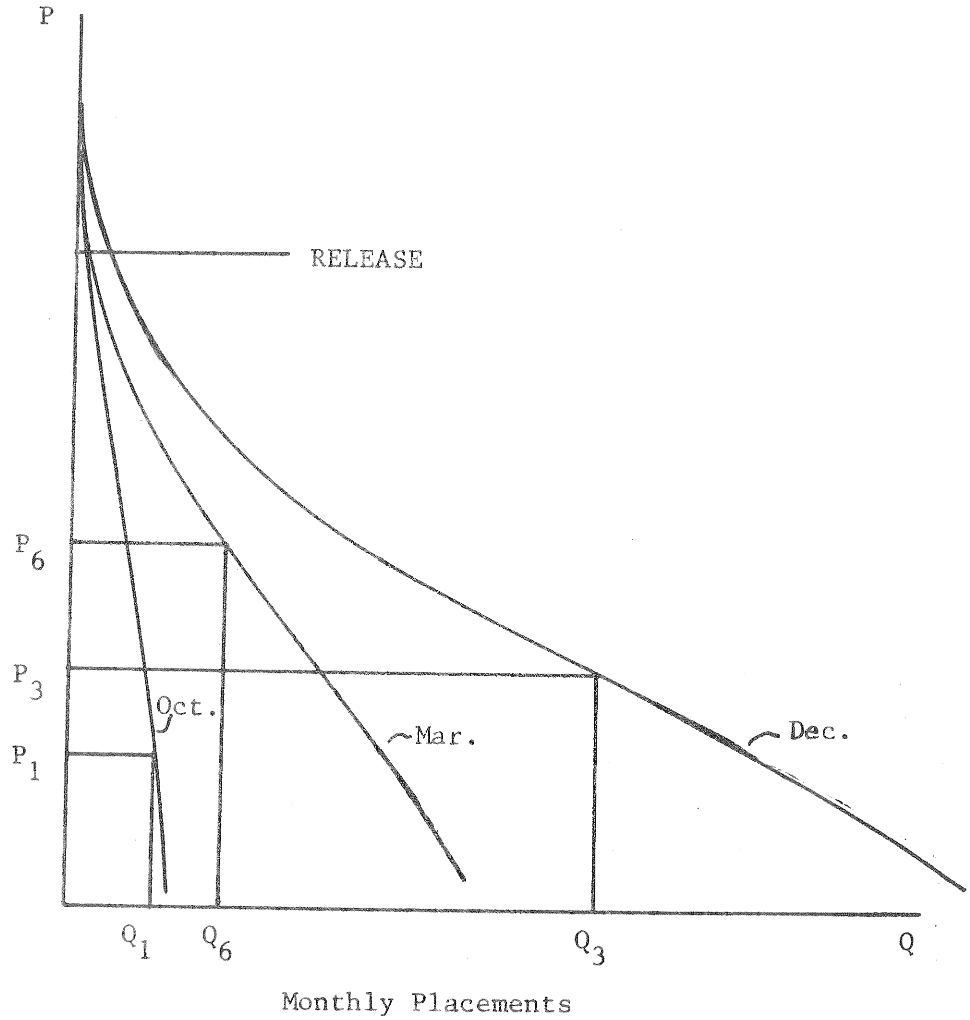

Figure 1. Monthly Corn Reserve Placements in a Typical Year

Q_1, P_1 = Placements and Price in October

Q_3, P_3 = Placement and Price in December

Q_6, P_6 = Placement and Price in March

Table 1. Placement Functions for Corn Estimated Over Two Time Periods[a]

Model	C (t)	PPV (t)	MKT (t)	PART (t)	R^2 (DW)	SSE (d.f.)
Ia	-7.096 (-1.69)	6.323 (3.33)	-5.151 (-3.81)		.79 (2.15)	1688 (11)
Ib	-9.469 (-2.05)	5.201 (2.76)	-2.679 (-1.25)	-2.737 (-1.02)	.81 (2.32)	1501 (10)
IIa	-24.858 (-2.02)	10.741 (2.22)	-3.688 (-3.84)		.74 (0.97)	70379 (30)
IIb	-24.499 (-2.51)	11.935 (2.81)	-3.862 (-4.54)	-3.381 (-2.83)	.79 (1.16)	57304 (29)

[a] Time period I is Oct. 1979-Nov. 1980

Time period II is period I plus Mar. 1981 to Sept. 1982.

the models, but they are not very stable as specifications and time periods are changed.

Placement Forecasts

While these models were developed for structural analysis of reserve behavior, our task here is to use them as forecasting models. We look first at the performance of different models in forecasting cumulative placements in 1979/81, 1981/82 and 1982/83 with prices given, then combine the best of these with a simple price forecasting equation to predict monthly and cumulative placements in 1982/83.

The model used for the forecasts in Table 2 includes the following relationships:

(7) $QAP_t = PART * PROD * (HARV_t - SLD_t) - (1 - SLD_t) *$
$(CPLACE_{t-1} - CREDEEM_{t-1} - BRS_1)$

(8) $QP_t = QAP_t / \{1 + \exp[-(\hat{\alpha} + \hat{\beta} MKT_t + \hat{\gamma} PPV_t + \hat{\delta} PART)]\}$

(9) $CPLACE_t = CPLACE_{t-1} + QP_t$

where variables are as previously defined in equations (4), (5) and (6) except the annual subscripts are omitted. New variables are cumulative placements (CPLACE) and redemptions (CREDEEM). Within each year, QAP, QP and CPLACE are endogenous.

The performance of these models in simulating the cumulative placements over the estimation periods and one or two prediction intervals outside the estimation period varies with the model (Table 2). Model I performs well over its estimation period and over the first five months of 1982/83, but performs poorly in the 1981/82 crop year. It seems that a major reason for

Table 2. Performance of Placement Models in Estimating Cumulative Placements by Crop Year.

	1979/80	1981/82	1982/83[a]
Actual	368	1328	1328
Model Ib			
Estimated (mil.bu.)	355	734[b]	1394[b]
Error (mil.bu.)	-13	-594	67
Percent error	-3.5	-44.7	5.0
Model II			
Estimated (mil.bu.)	32	1588	1445[b]
Error (mil.bu.)	-336	260	118
Percent error	-91.3	19.6	8.8
Model IIb			
Estimated (mil.bu.)	315	1583	1875[b]
Error (mil.bu.)	-55	255	549
Percent error	-14.9	19.2	41.2

[a] Up to Feb. 28, 1983.

[b] Outside the estimation period.

this outcome is that the participation rates in 1979/80 and 1982/83 are similar (21 and 23 percent), while 1981/82 had near 100 percent eligibility. Model IIa performs better in 1981/82, nearly as well in 1982/83 but very poorly in 1979/80. Model IIb performs fairly well in both periods of the estimation interval but poorly in the prediction interval.

It is very interesting that all specifications of the model err on the high side in forecasting placements in 1982/83. By contrast, few if any analysts in the Fall of 1982 anticipated the large placements that have been observed this year. The USDA forecast on October 13, 1982, was for additions of 740 million bushels during the year. Note that in 1979/80 with a similar program participation rate, farmers put about 20 percent of eligible production in the reserve while in 1982/83 placements were nearly 70 percent of eligible production. Yet the equation estimated over the 1979/80 period provides the best forecast. Most of the explanation lies in the large differential this year between the very high reserve loan and the very depressed market prices. As reflected in our model, the difference between PPV and PMKT reached $1.08 this year compared with a maximum of about $.30 during 1979/80.

<u>Price and Placement Forecasts</u>

The model given in equations doesn't represent a true forecast, because actual prices in 1982/83 are used. To indicate how this model may be linked to price forecasting equations or models we add, alternatively, two very simple monthly price forecasting equations. Using Model Ib we then repeat the forecast of 1982/83 placements. The price equations are:

$$(10)\quad PMKT_t = \alpha_0 + \alpha_1 \, PMKT_{t-1} + \sum_{i=1}^{11} \beta_i D_i + u_t$$

$$(11)\quad PMKT_t = \alpha_o + \alpha_1 \, APMKT + \sum_{i=1}^{11} \beta_i D_i + v_t$$

where

D_i = 1 in the ith month, -1 in the 12th month, 0 elsewhere

APMKT = the season average farm price.

For our purpose, use of equation (10) requires knowledge only of the September 1982 corn price. Use of equation (11) requires a forecast of the annual season average price for 1982/83. Although much better price forecasting models could be obtained, our purpose is served with these simple relationships.

The parameters are estimated over the crop years 1976/77 to 1981/82 (Table 3). The placement forecasts obtained with the prices are presented in Table 4. The monthly placement forecasts leave much to be desired, but the errors in cumulative placements range from 1.4 to 15.7 percent and all the turning points are correct. Again, all the forecasts are much closer to actual placements than was the USDA forecast of October 13.

Implications for Further Research

What we have reported is still very much a partial equilibrium analysis. A more general model would include a reserve redemption function, since placements and redemptions sometimes occur within the same year and even within the same month. Both are needed to forecast quantities in

Table 3. Corn Price Forecasting Equations, 1975/77-1981/82
(t in parentheses)

Intercept	0.084 (0.99)	0.073 (0.43)
LPMKT	0.963 (27.87)	-
SAPMKT	-	0.967 (14.04)
D1	-0.067 (0.67)	-0.115 (1.81)
D2	-0.030 (0.67)	-0.147 (1.81)
D3	0.106 (2.34)	-0.042 (0.51)
D4	0.066 (1.47)	0.020 (0.25)
D5	0.002 (0.04)	0.015 (0.18)
D6	0.045 (1.00)	0.053 (0.66)
D7	0.031 (0.70)	0.077 (0.95)
D8	0.037 (0.83)	0.105 (1.30)
D9	0.007 (0.15)	0.102 (1.26)
D10	-0.002 (0.04)	0.090 (1.11)
D11	-0.121 (2.68)	-0.04 (0.49)
R_2	.93	.78
$\hat{\rho}$	0.533	0.670

Table 4. Forecast of Corn FOR Placements for 1982/83 Using Simple Monthly Price Equations (million bushels).

	Actual	Actual Prices	Price Equation 10	Price[a] Equation 11
October	67	122	109	84
November	208	363	398	330
December	457	532	582	489
January	453	258	279	265
February	142	119	167	177
Cumulative	1327	1394	1535	1345

[a] The USDA October 13, 1982, price forecast of $2.40 was used.

the reserve. Moreover, these models of reserve behavior should be linked to monthly, quarterly or even annual supply and demand models to endogenize reserve quantities. Such links need to include the interaction between reserve stock levels and free stocks. Better understanding of the interactions between reserve quantities and other market and policy factors will help market analysts anticipate the implications of changing reserve provisions and help government analysts evaluate the consequences of policy options.

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