A Method for Adapting a Monthly Behavioral Relationship for Use in an Annual Model

by

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Modeling the farmer-owned grain reserve in an annual framework presents a special challenge to the modeler. The design of this program is such that in a number of years the quantities in the reserve should be modeled as simultaneously determined with prices. The ordinary way to do this is to add an additional equation to the model to represent the behavior of the farmer-owned reserve quantities as a function of prices and policy variables. Econometric estimation of the parameters of such a model, however, is not possible, because of the short annual data series available. The program just began in 1977 and program provisions were changed more frequently than annual data would reflect, so parameter estimation with annual data really isn't feasible. Behavioral parameters for the reserve program have been estimated with quarterly data by Smyth and with monthly data by Meyers and Smyth. It is the monthly model which is used in this paper to develop an annual reserve relationship.

Method

The problem posed here is to develop our annual reserve placements relationship which reflects the behavior of a monthly econometric model. The monthly model is highly nonlinear and of the form

(1) $$Q_{mt} = f(P_{mt}, X_{mt}, Z_t)$$

where

P_{mt} - price in month m, year t

X_{mt} - monthly variable in year t

Z_t - annual variable in year t

Annual placements equal the sum of monthly placements during the year

(2) $$Q_t = \sum_{m=1}^{12} Q_{mt}$$

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The desired annual model is a linear approximation of the form

(3) $$Q_t = \pi_o + \pi_p \bar{P}_t = \pi_s \bar{X}_t + \pi_z Z_t$$

where

$\bar{P}_t$ - annual average of monthly prices P

$\bar{X}_t$ - annual average of monthly values of X_{mt}

The coefficients are derived from the monthly model as follows:

(4) $$\pi_p = \frac{\partial Q_t}{\partial P_t} = \sum_{m=1}^{12} \frac{\partial Q_{mt}}{\partial P_{mt}}$$

(5) $$\pi_x = \frac{\partial Q_t}{\partial X_t} = \sum_{m=1}^{12} \frac{\partial Q_{mt}}{\partial X_{mt}}$$

(6) $$\pi_z = \frac{\partial Q_t}{\partial Z_t} = \sum_{m=1}^{12} \frac{\partial Q_t}{\partial Z_t}$$

(7) $$\pi_o = Q_t - \pi_Z Z_t - \pi_x \bar{X}_t - \pi_p \bar{P}_t$$

Computation of the Annual Placement Coefficients

The specification for annual farmer-owned reserve placements is listed below:

(8) APLACE = f_1(CORPF, CORRE, PRES, ICCC, TBILL, CORPGR, CPART, SPMT)

This annual placement function includes most of the major market and policy factors that affect producers' placement decisions.

Price received (CORPF) is expected to negatively influence placements in the reserve. Another market influence is the three-year treasury bill rate (TBILL) which reflects the long term general interest rate and acts as a measure of opportunity cost. If this rate increases, potential reserve participants would be less inclined to place corn in the reserve. Instead, they would be more inclined to sell the grain and invest the cash receipts at the higher interest rate reflected by TBILL.

Current production (CORPGR) has a positive expected sign, because *ceteris paribus* large levels of production would induce more reserve placements.

The remaining elements reflect program influences on annual placements. The reserve entry price (CORRE) is the reserve loan rate. Higher loan rates tend to induce more participation in the program by increasing producers' expected returns from storage. The release price (PRES) is a predetermined market price at which grain from the reserve is allowed to be redeemed without penalty. At this point direct storage subsidies cease. Higher release prices would be expected to increase reserve placements, because it increases the expected sales price at redemption. The CCC interest rate (ICCC) is the interest charged on reserve loans. A higher rate means that the interest expense to participants will be greater, which acts as a disincentive to reserve participation. Storage payments (SPMT) are a direct subsidy paid to reserve participants to store their grain. An increase is expected to induce more placements.

The technique described in the previous section is employed to estimate the coefficients for this equation. The coefficients for the annual placement equation listed above are derived from the simulation of a monthly reserve placement model during "direct entry" years only (1979, 1981, 1982). Once the coefficients for the annual placement equation are derived, we then place it back into the complete U.S. corn model to be used in the estimation of the other parameters and the simulation analysis. For the years 1977, 1978, and 1980, when direct placements did not occur, the exogenous values for placements are used.

The monthly model used in this technique was initially developed by Meyers and Jolly (1980) and further developed by Meyers, Jolly, and Smyth (1983a,b) and Meyers and Smyth (1984). In the development and use of their model they assume 1) that farmers rationally compare the expected returns and benefits from reserve participation to the expected returns from alternative uses of the grain, 2) there is a cash price as the alternative to which reserve participation is compared, and 3) there is a maximum quantity of grain available for placement.

What follows is a brief description of the Meyers et al. (1983b) placement model. The general specification for monthly reserve placements is shown below:

(9) $QP_m = f_2(MKT_m, PPV_m, QAP_m, PART_m)$

where the m subscripts represent monthly periods and where

MKT = market price for corn,
PART = participation rate for the acreage reduction programs,
PPV = present value from storage,
QAP = quantity of corn available for placement,
QP = quantity placed into the reserve.

The market price is inversely related to monthly placements. The present value variable is a summary variable that includes most of the policy and market factors that affect the present value from reserve storage. Any policy or market factor that increases expected returns from reserve storage increases placements. Larger quantities available for placement and/or larger participation will also increase placements.

Meyers and Smyth (1984) chose a logistic function as the form to estimate the monthly coefficients. Equations (10) through (15) show the structure of their model and the estimated coefficients they obtained are given in (10).

(10) $$PLACE_m = \frac{AVAIL_m}{1 + \exp[-(-7.75 - 1.92(CORPF_m) + 3.74(PPVMAX_m) - 1.30\ (PART_m)]}$$

(11) $$AVAIL_m = (HARV_m - SLD_m)(PART_s)(CORPGR_s) - (1-SLD_m)(BRS_{sm} - BRS_{s1})$$

(12) $$PPVMAX_m = MAX(PPVDEF_m, PPVRED_m)$$

(13) $$PPVDEF_m = CORRE_m + \sum_{j=1}^{T} \frac{SPMT_m - SCOST_m}{(1 + TBILL)^{j-1}}$$

(14) $$PPVRED_m = PPVDEF_m + \frac{.97(PEXP) - (1 + ICCC_m * YRINT_m)\ CORRE_m}{(1 + TBILL_s)^T}$$

(15) $$PEXP_m = 1.10 * (PRES_m)$$

where subscript m = month, subscript s = crop year, and superscript T = number of years the grain is held in the reserve. The variable definitions are:

PLACE = monthly placements in the reserve,

AVAIL = quantity available for reserve placement,

BRS = beginning reserve stock level,

CORPF = price received by farmers,

CORRE = reserve loan rate,

CORPGR = production for the crop year,

HARV = proportion of corn harvested by month m,

ICCC = CCC interest rate,

PART = reserve participation rate for the crop year,

PEXP = expected sales price,

PPVDEF = present value of defaulting on the loan,

PPVMAX = maximum present value of defaulting or redeeming the reserve loan,

PPVRED = present value of redeeming the loan,

PRELS = reserve release price,

SCOST = storage cost per bushel,

SLD = proportion sold by month m,

SPMT = storage payment rate per bushel,

TBILL = three-year treasury bill rate,

YRINT = number of years interest is charged on reserve loans.

As mentioned earlier, the coefficients for Equation (10) were estimated for the direct entry periods. Direct entry was permitted in 1979, 1981, and 1982 when producers were allowed to participate in the reserve without first participating in the nine-month loan program. The signs on the estimated coefficients appear to be theoretically correct.

The identity for monthly quantities available for placement is shown in Equation (11). The first term in this equation measures the quantity of eligible grain harvested but not yet marketed at the beginning of month m in crop year s. The second term measures the quantity of grain removed from available supplies as a result of placements since the first month of the crop year. The following assumptions regarding available grain supplies for placement are made:

1) only set-aside participants are eligible for placements,

2) grain reserve placements reduce availability, but redemptions increase availability by substitution with new crop grain,

3) grain marketing reduces availability.

The present value variable in (12) reflects producers' decisions to take the option with the highest return; either default on the loan or redeem it. Equations (13) and (14) show the computations for both options. The default option becomes attractive if the loan rate is too high relative to the expected sales price. The expected sales price is assumed to be 110 percent of the release price.

In Equation (14), shrinkage and quality deterioration are reflected by the 0.97; 3 percent of the corn is assumed to become unusable during the storage period. Two years is assumed to be the maximum storage time.

We can now proceed to describe the method used to calculate the annual coefficients for Equation (8).

Using the described Meyers et al. (1983b) model, 12-month simulations were run for each crop year listed in Table 4.1. These simulations yielded "base values" for reserve placements for each crop year. These base values, by the way, were close to the actual placement values at each crop year's end as reported by the USDA.

Next, the variables in the monthly model were shocked to see how placements would be affected. Table 1 shows the actual or base value of each variable and the shock it was given. The values listed for CORPF, ICC, and TBILL are the crop year averages. In the monthly data, these three variables

Table 1. Base values for the annual placement variables and the administered shocks[a]

Variable	1979/80 base	1979/80 shock	1981/82 base	1981/82 shock	1982/83 base	1982/83 shock
CORPF[b]	2.52	±.25	2.50	±.25	2.68	±.25
CORRE	2.10	±.25	2.55	±.25	2.90	±.25
PRELS	2.63	±.25	3.15	±.25	3.25	±.25
ICCC[b]	0.09	±.02	0.139	±.02	0.094	±.02
TBILL[b]	0.110	±.02	0.139	±.02	0.102	±.02
CORPGR	7339.00	±200	8201.00	±200	8359.00	±200
CPART	.211	±.20	1.00	±.20	.23	±.20
SPMT	.265	±.10	.265	±.10	.265	±.10

[a]See page 6 for variable definitions.

[b]12 month average.

Table 2. Changes in annual placements resulting from administered shocks[a]

	1979/80		1981/82		1982/83	
	+.25	-.25	+.25	-.25	+.25	-.25
$\frac{\partial APLACE}{\partial CORPF}$	-121.87	186.63	-528.67	746.75	-252.60	214.43
$\frac{\partial APLACE}{\partial CORRE}$	35.84	-30.67	1455.22	-144.52	365.06	-256.10
$\frac{\partial APLACE}{\partial PRELS}$	123.88	-96.59	519.69	-124.63	2.20	0
	+.02	-.02	+.02	-.02	+.02	-.02
$\frac{\partial APLACE}{\partial ICCC}$	-36.13	39.38	-108.60	203.65	0	0
$\frac{\partial APLACE}{\partial TBILL}$	-15.25	16.65	-27.74	29.55	-9.78	10.01
	+200	-200	+200	-200	+200	-200
$\frac{\partial APLACE}{\partial PROD}$	8.81	-8.81	36.72	-36.72	30.86	-30.86
	+.2	-.2	+.2	-.2	+.2	-.2
$\frac{\partial APLACE}{\partial PART}$	194.56	-327.54	-71.33	-.3	877.77	-1109.09
	+.10	-.10	+.10	-.10	+.10	-.10
$\frac{\partial APLACE}{\partial SPMT}$	266.27	-165.88	1575.47	-712.0	388.51	-541.90

[a]See page 6 for variable definitions.

change from month to month, but for illustration only the averages are shown in this table.

Dynamic simulations of the monthly model were run for each shock given to each variable for each of the three crop years. Table 2 shows the impacts on annual placements resulting from each shock over the 12 month periods. The sizes of the administered shocks reflect reasonable guesses of possible variations for each variable. The shock sizes, in fact, approximate the standard deviation for many of the variables listed. These ranges seem large enough to provide realistic spreads in which each variable's coefficient can be computed.

Equations (16) through (19) summarize the steps used to compute the annual coefficients in Table 1 for each year.

(16) $$BV - IV_{+s} = CPV_{+s}$$

(17) $$BV - IV_{-s} = CPV_{-s}$$

(18) $$((CPV_{+s} - CPV_{-s})/2) * 1/S = \beta_i$$

(19) $$\alpha_0 = APLACE_t - \sum_{i=1}^{8} \beta_i X_i$$

Where BV = base value simulation results for placements,

IV_{+s} = impact value of placements resulting from a positive shock to the variable,

IV_{-s} = impact value of placements resulting from a negative shock to the variable,

CPV_{+s} = change in placements from a positive shock,

CPV_{-s} = change in placements from a negative shock,

S = size of the shock given to each variable,

α_0 = intercept term,

β_i = computed coefficient,

X_i = independent variable,

APLACE = actual quantity of placements at the end of the crop year.

The calculated coefficients and their corresponding elasticities are given in Table 3. They are not as good as if they had been estimated simultaneously within a supply and demand model. However, due to the limited reserve observations available, the technique used in calculating them has yielded proxies for the estimated coefficients that allow the reserve placement equation to be used endogenously in the supply and demand simulation.

Table 3. The coefficients for the annual placement function[a]

Variable	1979/80	1981/82	1982/83
CORPF	-581.00 [-3.97][b]	-2550.84 [-4.80]	-934.08 [-1.74]
CORRE	133.4 [.77]	3199.48 [6.14]	1242.32 [2.51]
PRELS	440.96 [3.14]	1289.64 [3.06]	4.40 [.009]
ICCC	-1888.00 [-.46]	-7806.50 [-.81]	0 [0]
TBILL	-800.00 [-.24]	-1433.00 [-.15]	-495.00 [-.04]
CORPGR	.044 [.95]	.1836 [1.13]	.1543 [.90]
CPART	1305.25 [.75]	179.10 [.13]	4967.15 [.80]
SPMT	2460.80 [1.77]	11437.40 [2.28]	4652.10 [.69]
INTERCEPT	-625.1	-7947.8	-3169.9

[a]See page 6 for variable definitions.

[b]Elasticities are in brackets.

Note that the calculated coefficients in Table 3 vary among years. This is due to the nonlinear nature of the reserve placement function. The coefficients are generally larger in 1981 as a result of high eligible participation, since there was no set-aside program. The coefficient for CPART in 1981, however, is comparatively small. With the large eligible participation for that year, the marginal effect of additional participation becomes small.

In 1982, the coefficient for the CCC interest rate (ICCC) is 0 and the coefficient for the treasury bill (TBILL) is only -495. These relatively small sizes are largely the result of the high loan rate for that year. The high loan rate caused the default option to dominate the redemption option, which caused the interest rate effects to be very small compared to other years. The release price coefficient (PRELS) in 1982 is also small for the same reason. The default option, as seen in equation (13), has a present value dependent only on the reserve loan, storage costs and storage payments.

Use of the Model

The addition of endogenous reserve stocks in a corn model makes it possible to evaluate the impact of changing reserve program provisions on prices, supply demand, and government cost. For this analysis attention was focused on placements. Redemptions, which occurred mostly in crop year 1980, are exogenous.

Figure 1 shows how the corn model performs in simulating reserve quantities when this equation is used. An example of the impact analysis is presented in Table 4. In 1982, a year when the reserve loan was exceptionally high, the reserve loan is reduced by \$.20, so it is \$.15 per bushel above the regular nine-month loan rate. The result is fewer reserve stocks, more stocks under nine-month loan, larger disappearance, lower market price, lower stock program costs, higher deficiency payment costs, and a decline in net program outlays. These results indicate that market conditions and government costs can be quite sensitive to changes in reserve provisions, so an improved ability of models to evaluate such changes is important.

The techniques employed in this paper are admittedly approximations and should be treated as such. These approximations could be improved if a complete quantity or monthly model were available from which to derive the reduced form annual model. This would make it possible to take into account endogenous price effects when generating the reduced form parameters for the policy variables.

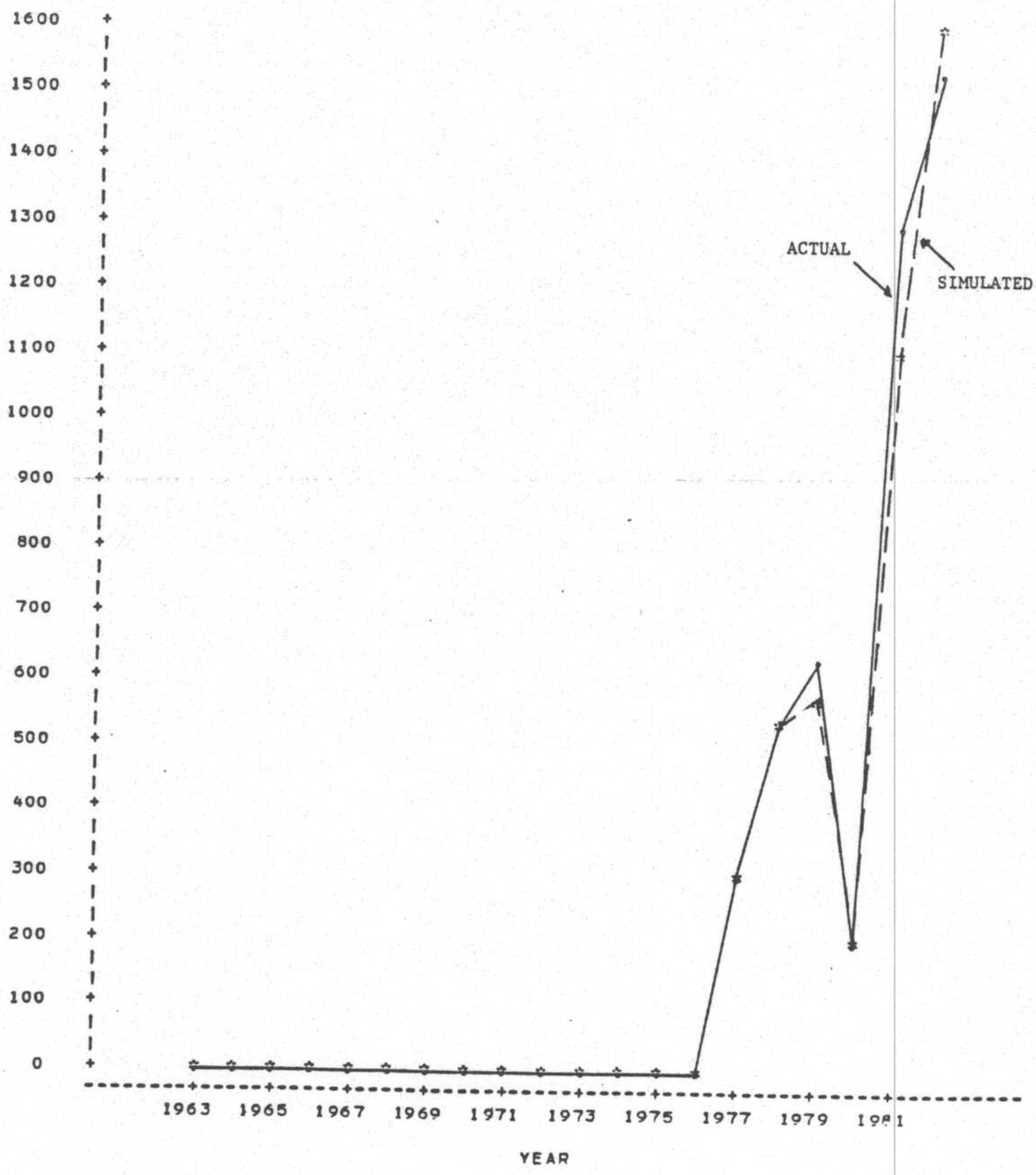

Figure 1. Plot of actual and simulated farmer-owned reserve carryover (CORHPRRE)

Table 4. Impact of a lower reserve loan rate and release price in 1982[a]

		1982
Corn price ($/bushel)	Actual	2.68
	Change	-.10
	Percent change	-3.7
Total stocks (mil. bu.)	Actual	3120
	Change	-52
	Percent change	-1.7
Private stocks excluding those under loan (mil. bu.)	Actual	293
	Change	5
	Percent change	1.7
Reserve stocks (mil. bu.)	Actual	1550
	Change	-158
	Percent change	-10.2
Carryover under nine-month loan (mil. bu.)	Actual	110
	Change	101
	Percent change	91.8
Disappearance (mil. bu.)	Actual	6906
	Change	52
	Percent change	.75
Total loans (mil. bu.)	Actual	1576
	Change	-40
	Percent change	-2.5
Nine-month redemptions (mil.bu.)	Actual	266
	Change	17
	Percent change	6.4
Deficiency payments (mil. $)	Actual	226
	Change	178
	Percent change	78.8
Net outlays (mil. $)	Actual	2114
	Change	-270
	Percent change	-12.8

[a]1982 reserve loan rate was lowered from $2.90 per bushel to $2.70 per bushel. The release price was lowered from $3.25 per bushel to $3.10 per bushel.

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