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EFFECTS OF PUBLIC STOCKHOLDING PROGRAMS UPON GRAIN STOCK
ENHANCEMENT*

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Grain -- Storage

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ABSTRACT

Effects of public grain stocks upon total stock enhancement were estimated for wheat and feed grains, 1973-85. Results indicate that government stocks have had a small or negligible effect upon enhancement of total carryover stocks of grain. The substitution effects ranged from 0.66 bushels for sorghum to 0.86 for barley.

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Introduction

Stockholding as a means of price stabilization has long been a policy tool of the U.S. Department of Agriculture. Several programs used to accumulate Government-owned or regulated stocks include the price support and nonrecourse loan programs, direct purchases, or the Farmer-Owned Reserve (FOR). FOR stocks are owned by producers but regulated by the Government. The Commodity Credit Corporation (CCC) has been the public corporation used to coordinate the purchase and sale of Government-owned grain.

The presence of a public stock holding program raises the question of whether private stocks may be held in optimal amounts in lieu of public stocks. Since the U.S. private storage industry approximates perfect competition (Caves, Stein et. al.), it is questionable whether public storage can be more cost effective than private storage in achieving price stability. Theoretically it has been shown that in a perfectly competitive economy, private storage will maximize net social welfare (Gustafson and Samuelson).

Despite this theoretical argument, the market may elicit storage behavior which deviates from the socially optimal storage behavior. Political considerations or a divergence between the social and private rate of return may justify the accumulation of public stocks. Public stockholding is conducted under the auspices of price stabilization while supporting prices and incomes of producers and providing for emergency humanitarian needs.

One of the objectives of these stockholding programs has been to

stabilize prices for program commodities by adding to total stocks.

Stocks are accumulated when prices are low and released when prices are high. In addition to stabilizing prices, Government stockholding programs can enhance producer prices in the short run. However, large Government stocks may have a negative effect on prices in later periods. Thus, the purpose of holding speculative stocks may be diminished by a Government stockholding policy.

The performance of these stockholding programs is of interest to policymakers. The proportion of total stocks owned by or obligated to the Government has become large for wheat and most feed grains. The Food Security Act of 1985 includes measures designed to reduce government stocks, such as generic certificates, and it has continued the FOR program but with size limitations. Much research evaluating the effectiveness of stockholding programs has found that Government stocks tend to have a price depressing effect and therefore reduce the private speculative demand for stocks (Gardner, Just, Sharples and Holland, Wright, and Salathe et. al.). In addition, FOR stocks were also found to affect the level of stocks owned by the CCC.

The remainder of this paper is organized in the following manner. Section 1 presents a theoretical model of storage assuming no Government intervention. In section 2, the relationship of a price band policy and the supply of storage are introduced. An empirical model of storage is presented in section 3, and in section 4 econometric estimates are reported of the total stock enhancement effects due to public stockholding programs. Concluding remarks are presented in section 5.

1. Competitive Storage In The Absence Of Government Programs

A purely competitive market for an annually produced storable commodity is considered first. The initial supply in crop year t , S_t , is composed of the amount carried over from the preceding crop year, I_{t-1} , plus the current harvest H_t :

$$(1) \quad S_t = I_{t-1} + H_t.$$

The amount harvested depends on Y_{t-1} , the expected production established during the previous planting season, and \tilde{w}_{t-1} , a stochastic term to represent the weather condition that prevailed during the previous growing season:

$$(2) \quad H_t = h_t(Y_{t-1}, \tilde{w}_{t-1}).$$

I_t is the amount stored in the current year and carried over to the following period and the remaining supply is consumed domestically, D_t , or exported X_t :

$$(3) \quad S_t = D_t(P_t, \tilde{u}_t) + X_t(P_t, \tilde{v}_t) + I_t,$$

where \tilde{u}_t and \tilde{v}_t represent stochastic disturbance terms.

Let k be the constant unit cost of storage, r be the interest rate and $E_t(P_{t+1})$ the price expected to prevail next year. Then it is the case that the discounted expected future price of the commodity must not exceed the cost of storing one unit of the commodity:

$$(4) \quad E_t(P_{t+1}) - (P_t + k)(1+r) \leq 0$$

Otherwise, risk-neutral, expected profit maximizing arbitragers would exploit profit opportunities by purchasing stocks. On the other hand, there is a disincentive to hold speculative stocks if the opportunity cost of storage exceeds the discounted expected future price:

$$(5) \quad [E_t(P_{t+1}) - (P_t + k)(1+r)]I_t = 0.$$

Producers make their production decisions based on the expected future price:

$$(6) \quad Y_t = q_t(E_t(P_{t+1})).$$

The supply available at the beginning of year $t+1$ will be the sum of the

current carryout and next period's harvest, which depends on the current production plans and the intervening weather conditions:

$$(7) \quad S_{t+1} = I_t + H_{t+1}.$$

Lastly, it is assumed that producers and inventory holders believe price in period $t+1$ is determined by the supply available at the beginning of that period, but they possess only a probabilistic distribution of the intervening weather and stochastic demand shifters:

$$(8) \quad E_t(P_{t+1}) = f_t(I_t + H_{t+1}; \Omega_t)$$

where Ω_t is the set of available information concerning the market parameters given in equations (1) - (7).

Expectations are assumed rational; that is, they are consistent with those of the model. The actual relation between expectations and the information set is not generally expressable in closed form, but must be estimated numerically (see Gardner 1979, Wright and Williams, Plato and Gordon, Lowry et. al.).

Similarly, from this model it can be shown how expected carryout can also be expressed as a function of available supply and Ω_t :

$$(9) \quad E_t(I_{t+1}) = i_t(I_t + H_{t+1}; \Omega_t).$$

This is the optimal storage rule first described by Gustafson.

2. The Optimal Storage Rule With Government Price Band Policies

The presence of a buffer stock scheme affects the formulation of the optimal storage rule. Suppose that the Government stands ready to purchase unlimited quantities of a commodity at a specified support price P^f . Thus the market price P_t will never fall below this price floor:

$$(10) \quad P_t \geq P^f.$$

If the market price exceeds the support price, then no one will sell to the Government at the lower price it offers and Government stocks, G_t , will not grow. Thus,

$$(11) \quad \text{if } P_t > P^f \text{ then } G_t \leq G_{t-1}.$$

Suppose the Government also stands ready to sell from its inventory if the market price exceeds a release price P^c . The market price will never rise above the release price as long as there are Government stocks available for sale:

$$(12) \quad \text{if } P_t > P^c \text{ then } G_t = 0.$$

If the market price is below the release price, no one will purchase from the Government and hence its inventory holdings will not decrease:

$$(13) \quad \text{if } P_t < P^c \text{ then } G_t \geq G_{t-1}.$$

Adding Government to the model developed in the previous section we rewrite equations (1), (3) and (7) to obtain:

$$(1') \quad S_t = I_{t-1} + H_t + G_{t-1},$$

$$(3') \quad S_t = D_t(P_t, \tilde{u}_t) + X_t(P_t, \tilde{v}_t) + I_t + G_t,$$

$$(7') \quad S_{t+1} = I_t + H_{t+1} + G_t.$$

The addition of a buffer stock scheme affects price expectations of producers and private inventory holders. Miranda and Helmberger have shown that it is possible to express price expectations as a function of current private carryout, production, and Government inventory:

$$(8') \quad E_t(P_{t+1}) = f_t(I_t + H_{t+1}, G_t; \mathcal{S}_t).$$

Likewise, we can rewrite the expected carryout equation:

$$(9') \quad E_t(I_{t+1}) = i_t(I_t + H_{t+1}, G_t; \mathcal{S}_t).$$

In addition, a relationship exists that relates total inventories to the predetermined variables in (8') and (9'):

$$(14) \quad E_t(I_{t+1} + G_{t+1}) = g_t(I_t + H_{t+1}, G_t; \mathcal{S}_t).$$

Previous research demonstrates that as price support levels are

increased, Government stocks increase and private inventories decline.

Thus, while Government stocks add to the total available supply, the relationship is less than one-to-one since private stocks are declining.

This substitution of public stocks for private stocks has been the focus of recent empirical research on the efficacy of the FOR and CCC in adding to total stocks (see Gardner, Just, Meyers and Ryan, Salathe et.

al., Sharples and Holland, Wright). For corn, estimates vary from a low of 0.25 bushels reported by Salathe et. al. to between 0.6 and 0.8 bushels estimated by Meyers and Ryan. Most recently, Wright estimated that a one bushel increase in CCC and FOR would yield a 0.63 and 0.19 increase in total corn stocks, respectively. The estimated effects on total wheat stocks of an increase in FOR ranged from a low of 0.19 bushels (Wright) to almost 0.87 bushels (Sharples and Holland).

4. Model Specification

From the theoretical model above, an empirical model can be estimated that measures the effect of Government stocks on total stocks. The model represents a reduced form of equation (14):

$$(15) \text{ Total Stocks}_t = a_0 + a_1 \text{ Supply}_t + a_2 \text{ GOVT}_t + a_3 \text{ Interest}_t.$$

where,

Total Stocks_t = Private carryout plus Government inventories (CCC plus FOR) at the end of period t .

Supply_t = Total available supply (production plus total stocks) at the beginning of period t .

GOVT_t = Total Government stocks (CCC + FOR) at the beginning of period t .

Interest_t = The annual rate of interest of a 6 month Treasury Bill during period t .

Total stocks and supply variables were adjusted by outstanding export sales. Since export shipments are often made several months after the actual sale, shipment data do not necessarily correspond to price data. Recent research by Ruppel advocates the use of export sales data as an alternative to shipment data, yet these data are potentially misleading in that sales are often based on forward prices rather than the current cash price. Following Ruppel we consider outstanding export sales as "encumbered" stocks and deduct them from total stocks and supplies.

Over low levels of initial supply, speculative carryout is zero.

Arbitragers will carry no stocks unless the discounted expected price exceeds the cost of purchasing and storing the commodity. Nonetheless, pipeline stocks are often carried over into the new crop year. Following Gardner (1982), binary variables are included as intercept and slope shifters during the last quarter of the marketing year (when pipeline stocks compose a large proportion of total ending private stocks).

Equations were estimated from data covering marketing year quarters from 1973,II - 1985,IV for wheat and feed grains. Thus, 1974-I begins June 1, 1974 for wheat, barley and oats and October 1, 1974 for corn and sorghum. This time period was selected to represent a period of time of strong export demand and fluctuating exchange rates relative to the 1960s or 1950s.

3. Results

Estimated carryout equations for wheat and feed grains, 1973-85, are presented in table 1. In these equations CCC and FOR stocks were aggregated into a GOVT variable because the FOR did not exist prior to 1977.

The fourth quarter intercept shifters were negative for all commodities, as expected, but significant only for wheat. The slope shifters were not significant for all variables, indicating that the explanatory variables' effect on interyear storage is not significantly different than their effect on intraseasonal storage.

The coefficient for the supply variable (marginal propensity to store) has a positive sign for each commodity and is significant. A one bushel increase in the supply variable results in the following increases in carryover stocks--.55 for wheat, .68 for corn, .58 for sorghum, .75 for barley, and .79 for oats.

The interest rate variable was hypothesized to shift the supply of

Table 1. Estimated Carryout Equations for Wheat and Feed Grains, Crop year 1973-85 a/

Explanatory Variable b/	:			Commodity						
	:	Wheat	:	Corn	:	Sorghum	:	Barley	:	Oats
Constant	:	423.299		167.411		33.969		1.568		-25.861
	:	(4.654)		(.651)		(.811)		(.105)		(-1.792)
D ₄	:	-337.050		-686.373		-61.043		-34.962		-66.018
	:	(-2.204)		(-1.508)		(-.960)		(-.852)		(-1.440)
Supply	:	.553		.675		.581		.746		.791
	:	(23.466)		(23.856)		(17.001)		(25.777)		(43.640)
D ₄ *Supply	:	.214		.117		.114		.162		.135
	:	(1.788)		(.723)		(.580)		(.918)		(1.059)
Interest	:	-24.752		-24.169		-4.120		-1.287		.396
	:	(-2.725)		(-.907)		(-.999)		(-1.067)		(.426)
D ₄ *Interest	:	16.306		-18.393		3.489		.309		-.222
	:	(1.275)		(-.491)		(.612)		(.113)		(-.090)
GOVT	:	.313		.209		.340		.143		-.158
	:	(4.832)		(2.206)		(4.001)		(1.703)		(-1.933)
D ₄ *GOVT	:	-.109		-.013		-.062		-.238		-.216
	:	(-.753)		(-.056)		(-.296)		(-.853)		(-.708)
R ²	:	.974		.974		.951		.974		.982
D.W. <u>c/</u>	:	1.989		1.994		2.001		1.802		1.263

a/ Second quarter of 1973 through fourth quarter of 1985.

b/ T-ratios are in parentheses.

c/ Adjusted for autocorrelation

storage function downward, thereby lowering carryover stocks. Results from table 1 support the hypothesized relationship. For example, as the three month treasury bill rate increases one percentage point, carryover stocks of wheat, corn, sorghum, and barley decline by 24.8, 24.2, 4.1, and 1.3 million bushels, respectively. An increase in interest rates increases the cost of storage, thus causing the carryout function to shift downward for a given level of supply and GOVT.

Results for the interest rate variable on oats did not support the hypothesized relationship. The coefficient had a positive rather than negative sign but it was statistically insignificant. Apparently interest rates do not affect the storage of oats since most of oats will be stored on the farm by farmers, regardless of interest rate variation. For example, about 60 percent of the oats produced are consumed on farms where produced and thus never enter commercial marketing channels. Also, about 80 to 85 percent of all oats are stored on the farm.

The Government stock variable, GOVT, was included because it was believed that it would shift the supply of storage function upward, thereby increasing carryover stocks. As hypothesized, the coefficient for this variable was positive and significant for each crop except oats. For each one bushel addition to government stocks, total carryover stocks increased by .31 bushels for wheat, .21 bushels for corn, .34 bushels for sorghum, and .14 bushels for barley. Thus, each additional bushel of grain stored by the Government displaces .69, .79, .66 and .86 bushels of private stocks for wheat, corn, sorghum, and barley, respectively.

The Government stock variable for oats had a negative sign rather than positive. Several explanations can be given for this finding. First, due to declining production over the 1973-85 period the general level of stocks also declined. Second, CCC and FOR stocks declined from 126.1 million bushels in 1973 to zero in 1977. While GOVT levels built up to about 45 million bushels in 1978, they declined to very low

levels thereafter. Thus as GOVT levels grew in the late 1970's total stocks were declining. Participation rates of oat producers in Government programs have always been low. While oats have had price support protection during this period, deficiency payments were not allowed until the 1982 crop year.

Estimated carryout equations for wheat and feed grains, 1977-85, are presented in table 2. This time period was selected because it coincided with the operation of the FOR program. The specification for the equations found in table 2 are similar to those found in table 1. The specification found in table 3 was added because it treats CCC and FOR separately, a specification used in recent studies by Gardner and Wright.

The results for wheat from table 2 are similar to those found in table 1. However, major differences were found with corn, sorghum, barley, and oats. The size of the GOVT coefficient for corn, sorghum, and barley was about one-half or less than similar coefficients found in table 1 and they were insignificant. Based on these results, the government stock holding program was ineffective in the more recent time period. Similar results were found by Gardner and Wright. In contrast, oats' coefficient for the GOVT stock variable had the correct sign and was significant, therefore suggesting an effective Government stock holding program.

Results from table 3 suggest that the effect of CCC wheat stocks on total stocks was positive (.61) and significant. Fourth quarter CCC corn stocks were positive (1.09) and significant, while the intra-year effects were negative (-.36) and insignificant. Apparently this reflects the fact that most nine month non-recourse loans are forfeited to the Government during the fourth quarter. The coefficient for CCC stocks of sorghum was positive (.27) but not significant, while barley's coefficient was positive (.71) and significant but oats' coefficient was

Table 2. Estimated Carryout Equations for Wheat and Feed Grains, Crop year 1977-85 a/

Explanatory Variable b/	:	Wheat	:	Corn	:	Sorghum	:	Barley	:	Oats
Constant	:	546.346		629.477		150.061		49.693		1.255
	:	(3.794)		(1.315)		(2.247)		(2.058)		(.076)
D ₄	:	-646.624		-1443.955		-298.534		-154.829		-6.160
	:	(-1.639)		(-1.715)		(-2.173)		(-1.687)		(-.097)
Supply	:	.515		.672		.601		.733		.777
	:	(16.963)		(19.850)		(16.224)		(22.599)		(40.497)
D ₄ *Supply	:	.455		.209		.424		.377		-.048
	:	(1.731)		(.977)		(1.633)		(1.463)		(-.289)
Interest	:	-25.723		-52.980		-12.400		-4.358		-1.987
	:	(-2.567)		(-1.347)		(-2.429)		(-2.625)		(-2.015)
D ₄ *Interest	:	21.149		16.807		17.912		5.844		-.505
	:	(1.090)		(.319)		(1.974)		(1.251)		(-.177)
GOVT	:	.307		.114		.160		.010		.400
	:	(3.992)		(.853)		(1.592)		(.103)		(2.464)
D ₄ *GOVT	:	-.288		.030		-.105		-.240		-.792
	:	(-1.194)		(.122)		(-.507)		(-.757)		(-1.215)
<u>R</u> ²	:	.969		.973		.961		.976		.987
D.W. <u>c/</u>	:	2.125		2.025		1.985		1.732		1.220

a/ Second quarter of 1977 through fourth quarter of 1985.

b/ T-ratios are in parentheses.

c/ Adjusted for autocorrelation

Table 3. Estimated Carryout Equations for Wheat and Feed Grains, Crop year 1977-85 a/

Explanatory Variable b/	:	Wheat	:	Corn	:	Sorghum	:	Barley	:	Oats
Constant	:	595.270		862.962		138.379		52.543		6.734
	:	(5.889)		(1.624)		(1.948)		(2.290)		(.552)
D ₄	:	-634.681		-930.425		-281.959		-152.641		40.034
	:	(-1.586)		(-1.085)		(-1.776)		(-1.393)		(.666)
Supply	:	.529		.671		.599		.733		.756
	:	(20.369)		(21.189)		(15.115)		(23.647)		(51.286)
D ₄ *Supply	:	.256		.036		.404		.350		-.175
	:	(.897)		(.159)		(1.137)		(1.082)		(-.986)
Interest	:	-28.747		-70.805		-11.727		-4.301		.648
	:	(-4.086)		(-1.642)		(-2.210)		(-2.750)		(.707)
D ₄ *Interest	:	25.836		2.692		16.870		5.656		-4.834
	:	(1.333)		(.054)		(1.683)		(1.191)		(-2.050)
CCC	:	.609		-.359		.268		.709		-14.173
	:	(4.666)		(-1.032)		(1.019)		(1.831)		(-4.526)
D ₄ *CCC	:	-.151		1.092		-.140		-1.027		15.985
	:	(-.335)		(1.743)		(-.245)		(-1.016)		(2.064)
FOR	:	.104		.234		.148		-.174		.902
	:	(1.363)		(1.369)		(1.445)		(-1.300)		(5.648)
D ₄ *FOR	:	-.019		-.252		-.099		.006		-.859
	:	(-.086)		(-.760)		(-.445)		(.016)		(-1.105)
<u>R</u> ²	:	.976		.976		.961		.979		.993
D.W. <u>c/</u>	:	1.820		2.134		1.956		1.768		1.249

a/ Second quarter of 1977 through fourth quarter of 1985.

b/ T-ratios are in parentheses.

c/ Adjusted for autocorrelation

negative (-14.173) and significant. Apparently declining total oats stocks, but nearly constant and low level of CCC stocks, explains the negative CCC coefficient for oats.

Results for the FOR coefficients were positive but not significant for wheat, corn and barley. The coefficient for barley was negative but not significant while the coefficient for oats was positive and significant. Nonetheless, the magnitude of the FOR coefficients for most commodities are smaller than those for the CCC coefficients. Care must be taken when interpreting these results since both variables are assumed to be independent when in fact they are related. Moreover, the high release levels for wheat and feed grains in recent years suggest that FOR stocks may be no different than CCC stocks in their effect on total stocks.

5. Conclusions

Government stocks were found to have a small effect upon enhancement of total carryover stocks over the 1973-85 estimation period. As Government wheat stocks rose, total wheat carryover stocks increased by .31 bushels. Enhancement effects for corn, sorghum, and barley were .21, .34, and .14 bushels, respectively. Those for oats were insignificant. The substitution effects of public for private stocks were as follows: one bushel increase in public stocks reduced private carryover stocks by .69 bushels for wheat, .79 bushels for corn, .66 bushels for sorghum, and .86 bushels for barley. Generally, greater rates of public/private substitution were found over the 1977-85 period when the FOR existed.

The results cast doubt on the ability of Government programs to add to total stocks. Under current price support and release levels, total Government stocks have increased but apparently at the expense of private stocks. More research is necessary to examine whether there are more cost effective ways of increasing total stocks such as subsidies to private inventory holders (see Gardner, Lowry et. al.).

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