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REEXAMINING THE INTERACTION BETWEEN PRIVATE AND PUBLIC STOCKS

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Reexamining the Interaction between Private and Public Stocks

Practitioner's Abstract: *It is commonly-accepted that public stocks reduce private stocks. In contrast, empirical estimates range from no displacement to 100 percent displacement. Utilizing the concept of options, a conceptual model was developed. It implies the displacement effect is nonlinear, decreasing as public stocks increase. Displacement reaches zero when public stocks are large enough to cover all shortfalls in quantity demanded at the public stock release price. In addition, the displacement effect depends on the slope parameter of the commodity's demand equation, the probability distribution of price, and the relationship between market price and public stock release price. A bootstrap regression analysis of carryout stocks of U.S. wheat from the 1953-54 though 1971-72 crop years was conducted. Consistent with the conceptual model, the displacement effect decreased as the amount of public stocks increased. Zero displacement was reached when public stocks equaled 100 percent of annual consumption. The displacement effect of the first unit of U.S. wheat public stocks did not differ statistically from 100 percent. While this analysis finds that the displacement of private stocks is a substantial cost of a public stock policy, it also suggests that the accumulation of public stocks can enhance total stocks, especially if the country is willing to accept the large private stock displacement cost of the first units of public stocks. Thus, the policy decisions regarding public stocks are more interesting than if the displacement of private stocks by public stocks is either none or 100 percent.*

Keywords: public stocks, displacement, private stocks, U.S., wheat

Introduction

The run-up in farm commodity prices since 2006 has caused riots in some less-developed countries, captured the attention of policy makers around the world, and led to a number of white papers (Abbott, Hurt, and Tyner, 2008 and 2011; Organization for Economic Co-Operation and Development, 2008; Trostle, 2008; von Braun et al., 2008). The white papers attribute the price increase to the interplay of several supply and demand factors[1]. Most also note that, while low commodity stocks did not cause the price run-up, they provided little cushion to absorb the price shocks caused by other factors.

High prices of farm commodities historically have lead policy makers to explore the idea of building public stocks. The U.S. eliminated most public stocks of farm commodities in the *Federal Agriculture Improvement and Reform Act of 1996*, but a recent study examined the idea of reestablishing U.S. public stocks of grains (Schaffer, Hellwinckel, Ray, and De La Torre Ugarte, 2011). This study has been transformed into a proposal for the 2012 farm bill by the National Farmers Union. Moreover, many countries continue to hold public stocks of farm commodities.

It is commonly-accepted that private storage agents will reduce the stocks they hold when public stocks exist (see, for example, Miranda and Helmberger, 1988; and Dorosh, 2009). The rationale is that public stocks reduce the probability of high prices and thus the return that private stocks can earn when price increases. In contrast, empirical estimates of the displacement effect vary widely, ranging from no displacement effect (Just, 1981) to 100 percent displacement, i.e., each unit of public stocks displaces one unit of private stocks (Gardner, 1981).

Given the striking difference between the commonly-accepted hypothesis and the wide variation in empirical estimates, a conceptual model of the displacement effect is developed. The model, based on a call option associated with public stocks, provides several additions to the literature, including a nonlinear displacement effect and the importance of the relationship between the public stock release price and the market price. Both variables are missing in previous empirical analyses. Results from an empirical study of the carryout of private and public U.S. wheat stocks from the 1953-54 through 1970-71 crop marketing years are consistent with the conceptual model.

The paper is organized as follows. Empirical studies of the displacement of private stocks by public stocks are reviewed in the next section. Then, a conceptual model of the displacement effect is developed, followed by an empirical study of U.S. wheat carryout stocks. The paper ends with a summary, conclusions, and implications.

Empirical Studies of the Public Stock Displacement Effect

Peck (1977-78) conducted the first empirical study of the displacement of private stocks by public stocks. She found each bushel of wheat owned by the U.S. Department of Agriculture (USDA), Commodity Credit Corporation (CCC) displaced 0.12 bushel of private wheat stocks over the 1950-74 period. Using a somewhat longer 1950-79 observation period, Gardner (1981) found a statistically significant displacement effect of 0.42 for CCC wheat but a displacement effect for CCC corn that did not differ significantly from zero. Using a 10 percent test level, Just (1981) found no statistically significant displacement effect for both CCC corn and CCC wheat.

Displacement effect of Farmer-Owned Reserve[2] (FOR) grain upon private stocks also has been examined. Using data for the 1977-79 calendar years and a 10 percent test level, Gardner found a displacement effect for FOR corn and wheat that did not differ significantly from 1.00. In other words, each unit of FOR grain displaced one unit of private stocks. Using data for the 1977 and 1978 calendar years and a 10 percent test level, Just found a significant displacement effect of 0.81 for FOR wheat but a displacement effect for FOR corn that did not differ significantly from zero. In contrast, using data from the 1977 and 1978 crop years, Sharples and Holland (1981) found a 0.14 displacement effect for FOR wheat.

Taken as a group, the results of these empirical studies suggest little is settled regarding the size of the public stock displacement effect upon private stocks. Estimated displacement effects range from none to 100 percent for both corn and wheat.

Model of Public Stock Displacement of Private Stocks

Public stocks are accumulated by a government agency to be released when market price exceeds a public stock release price or when price is judged to be too high by policy makers. To simplify the discussion, it is assumed that a specific public stock release price is announced by the government and thus is known by the private market.

Existence of public stocks introduces a discontinuity into the private market's determination of price. If market price is less than the public stock release price, public stocks cannot augment the private market's supply. However, if market price exceeds the public stock release price, public stocks can augment private supply.

A discontinuity can be examined using options. The specific option of interest in the case of public stocks is:

$$(1) \qquad C_{t,t+n} = \int_{P_{PuSt}}^{\infty} (P_{t,t+n} - P_{PuSt}) f(P) dP$$

where C = value of a call option as of time t written for expiration date, t+n, with a strike price of P_{PuSt}, the public stock release price. The value of this option is the incentive, based on the information available to the market at time t, to carry private stocks from time t to time t+n to sell at prices higher than the public stocks release price.

This call option will have no value if the market at time t does not expect the market's price to exceed the public stock release price at time t+n. In other words, no incentive exists to hold private stocks to potentially sell at prices greater than the public stock release price. Hence, even if public stocks exist, they will not displace private stocks because the market does not expect the public stocks to be released.

This call option will have value if the market at time t expects the market's price to exceed the public stock release price at time t+n. If public stocks exist, then the market must rationally expect their release. The resulting increase in supply will cause the market to reduce its expectation that market price at time t+n will exceed the public stock release price, thus reducing the incentive to carry private stocks to sell at prices greater than the public stock release price. In short, displacement of private stocks occurs when the market assigns a positive probability to the release of public stocks, which usually will occur before public stocks are actually released.

The release of public stocks is not a response of private firms to higher market prices, but instead is a decision by government. It thus can be conceptualized as a leftward shift of the supply curve along a stationary demand curve. Hence, to analyze the impact of the expected release of public stocks on private stocks, assume the following inverse demand function exists:

$$(2) \qquad P = (\alpha/\beta) - (1/\beta) Q_D + (\varepsilon/\beta)$$

where P is price, Q_D is the quantity of demand, α and β are the intercept and slope of the demand function, and ε is a random variable with mean, 0, and variance, σ^2. The demand curve is assumed to be negatively sloped throughout, implying each price-quantity combination is unique.

Substituting equation 2 into Equation 1 transforms it into this quantity equivalent:

$$(3) \qquad C_{t,t+n} = \int_{0}^{Q_{PuSt}} ((\alpha/\beta) - (1/\beta) Q_{t,t+n} + (\varepsilon/\beta) - ((\alpha/\beta) - (1/\beta) Q_{PuSt} + (\varepsilon/\beta))) f(Q) dQ$$

where Q is the quantity of demand and Q_{PuSt} is the quantity of demand associated with the public stock release price.

Equation 3 can be simplified to:

$$(4) \qquad C_{t,t+n} = \int_0^{Q_{PuR}} (1/\beta)(Q_{PuSt} - Q_{t,t+n})\, f(Q)dQ$$

Whereas the call option of Equation 1 has value when price is greater than the public stock release price; the call option of Equation 4 has value when the quantity of demand is less than the quantity of demand associated with the public stock release price.

Assuming that public stocks are managed so that their release does not drive market price below the release price, the impact of public stocks, denoted as G, upon the value of the call option in Equation 4 can be stated as follows:

$$(5) \qquad C_{t,t+n} = \int_0^{Q_{PuSt}-G} (1/\beta)(Q_{PuSt} - (Q_{t,t+n} + G))\, f(Q)dQ$$

The release of G public stocks increases the quantity of the commodity available for consumption, thus reducing the probability that demand will be less than the demand associated with the public stocks release price and the size of this demand shortfall. In other words, releasing G public stocks reduces the probability that price will exceed the public stocks release price as well as the magnitude by which price exceeds the public stocks release price.

Taking the first derivative of Equation 5 with respect to G reveals the impact of having one more unit of public stocks when the market assigns a probability to the release of the public stocks. Using Leibniz integral rule,

$$(6) \qquad \begin{aligned} dC_{t,t+n}/dG = {} & (d(Q_{PuSt} - G)/dG) \bullet ((1/\beta)(Q_{PuSt} - (Q_{PuSt} - G + G))\, f(Q_{PuSt} - G)) \\ & + \int_0^{Q_{PuSt}-G} (\partial((1/\beta)(Q_{PuSt} - (Q_{t,t+n} + G))\, f(Q))/\partial G)dQ) \end{aligned}$$

Taking the partial derivative of the second term and noting that [(Q_{PuSt} - (Q_{PuSt} – G + G)] equals 0, Equation 6 simplifies to

$$(7) \qquad dC_{t,t+n}/dG = -(1/\beta) \int_0^{Q_{PuSt}-G} f(Q)dQ$$

As the quantity of public stocks increases, the value of the call decreases. Because this call is the incentive to carry private stocks to sell at prices above the public stock release price, the quantity of private stocks will decline as public stocks increase. Thus, equation 7 is consistent with the conventional argument that public stocks displace private stocks because public stocks reduce the potential to profit from increases in price.

Equation 7 adds three insights to this conventional argument. One is that the marginal displacement effect of adding one more unit to public stocks is positively related to the cumulative probability associated with situations in which supply is expected to be less than demand at the public stocks release price. In other words, the greater is the probability that market price will exceed the public stocks release price, the higher is the displacement effect, *ceteris paribus*. The second insight is that the marginal displacement effect of adding one more unit to public stocks is inversely related to the slope parameter of the demand function. The third insight is that, if public stocks are large enough to cover all demand shortfalls at the public stocks release price, then the marginal displacement effect equals zero since the call has a value of zero.

Given this situation, a one unit increase in public stocks will increase total stocks, i.e., the sum of private and public stocks, by one unit.

Taking the derivative of equation 7 with respect to G (i.e., the second derivative of equation 5 with respect to G) provides additional insights:

$$
\begin{aligned}
d^2C_{t,t+n}/d^2G &= d(-(1/\beta)\int_0^{Q_{PuSt}-G} f(Q)dQ)/dG \\
&= -(1/\beta)(d(Q_{PuSt}-G)/dG)\,f(Q_{PuSt}-G) \\
&= (1/\beta)\,f(Q_{PuSt}-G)
\end{aligned} \tag{8}
$$

Ceteris paribus, combining equations 7 and 8 implies that the rate at which public stocks displace private stocks decreases as the quantity of public stocks increase. Thus, the displacement effect is nonlinear, not linear as reported by previous empirical studies. Equation 8 also reveals that, *ceteris paribus*, the rate of decrease in the displacement effect of public stocks upon private stocks is a function of the probability distribution and the slope parameter of the demand function.

To summarize the conceptual model, no displacement of private stocks by public stocks occurs when there is no probability that market price may exceed the public stock release price. Displacement begins not when public stocks are released but when the market assigns a positive probability to their potential release. Once the market assigns a positive probability to the release of public stocks, the displacement of private stocks by public stocks is greatest for the first unit of public stocks, then declines with each additional unit of public stocks. Displacement eventually reaches zero when public stocks are large enough to cover all shortfalls the market currently expects in quantity demanded at the public stock release price. In addition, the model reveals that the displacement effect depends upon the probability distribution and upon the slope parameter of the demand function. The latter implies that the displacement effect may vary by commodity and may change over time if the demand function changes.

Data and Variable Measurement

This study examines empirically the displacement of private stocks by public stocks carried out from the 1953-54 though 1971-72 crop years for U.S. wheat[3]. Wheat was selected for analysis because it is a basic staple food for which U.S. public stocks existed over the observation period. The initial year of the observation period was determined by the removal in early 1953 of price controls imposed on farm commodities during the Korean War (U.S. General Services Administration). The last year was determined by the increase in both the level and volatility of prices that began during the 1972-73 crop year in response to a number of factors, including the Russian grain deal, declining public socks, production difficulties in the U.S. and around the world, and general price inflation (Kenyon *et al.*).

Carryout stocks were chosen for analysis for several reasons. First, carryout stocks are closely tracked by market participants as a measure of the balance between supply and demand. Second, USDA surveys stocks on farms and at commercial storage facilities four times a year, including the end of the crop year. These surveys provide the most comprehensive accounting of U.S.

stocks. Third, using annual data avoids statistical problems associated with overlapping samples as well as potential seasonality effects associated with harvest. Fourth, starting with Working (February 1934), academic studies of stock holding have often examined carryout stocks.

Carryout stocks are measured as the ratio of stocks to use. The conventional argument for this commonly-used measure is that, *ceteris paribus*, the level of stocks needs to increase as demand increases since stocks to allow an annual harvest to satisfy continuous consumption. Theoretical support for this argument is provided by Routledge, Seppi, and Spatt (2000). Use is commonly-measured as annual disappearance, but this study uses disappearance during the last quarter of the crop year. Compared with annual disappearance, disappearance during the last quarter of a crop year is more contemporary with the consumption demands being placed on stocks carried out of the crop year[4]. During the analysis period, the wheat crop year began on July 1 and ended on June 30. Disappearance of wheat during the last quarter of the wheat crop year was calculated as the difference between the stocks reported by USDA in its survey of stocks on April 1 and July 1 as reported in *Agricultural Statistics*. Because stocks-to-use is commonly calculated using annual consumption, use during the last quarter was multiplied by 4 to annualize it. Thus, stocks-to-use is calculated as the ratio of carryout stocks divided by annualized consumption during the last quarter of the crop year.

Public stocks of wheat were measured as stocks held by CCC. The amount of wheat that CCC owned on June 30 ranged from 8.5 percent (1967-68 crop year) to 120.7 percent (1959-60 crop year) of annualized use during the last quarter of the crop year (see Table 1). Private carryout stocks were measured as the difference between total carryout stocks and CCC stocks[5]. Private carryout stocks of wheat on June 30 ranged from 4.7 percent (1957-58 crop year) to 55.8 percent (1968-69 crop year) of annualized use during the last quarter of the crop year. Source for the data on stocks was USDA's *Agricultural Statistics*.

Private stocks are a function of the incentive to carry private stocks from time t and t+n. Since Working's seminal papers published in 1948 and 1949, a commonly-used measure of this incentive is the spread between futures prices at different maturities. For carryout stocks, the spread is usually measured as the price difference between futures contracts that expire latest in the old crop year and earliest in the next or new crop year. In this study, the old crop –new crop spread is measured using prices for the May and July futures contracts traded at the Kansas City Board of Trade (KCBOT). These contracts are for hard red winter wheat, the largest class of wheat grown in the U.S. Futures traded at Chicago and Minneapolis price soft red winter and hard red spring wheat, respectively. To avoid problems that can arise when using prices during a contract's delivery month, this analysis used futures prices for the last trading day of April.

The old crop – new crop spread is adjusted for the costs of storage as follows:

(9) $Spread_t = \ln(July_t) - \ln[May_t + (USTB_t \bullet May_t \bullet 0.1667) + (PS_t \bullet 0.1667))$

where,

$July_t$	= closing KCBOT July futures price on April 30 of year t
May_t	= closing KCBOT May futures price on April 30 of year t
$USTB_t$	= 3-month U.S. Treasury Bill Rate on April 30 of year t
PS_t	= annual storage charge paid by CCC for publicly stored grain for year t
0.1667	= proportion of a year between May and July

The three month Treasury Bill rate was obtained from the U.S. Federal Reserve Bank of St. Louis. Physical storage cost was obtained from the *Federal Register* (U.S. General Services Administration). May and July futures prices were obtained from the *Statistical Report of the Board of Trade of Kansas City.* The *Statistical Report* did not contain closing prices until the 1966 calendar year. Prior to 1966, it reported only the low and high prices for the trading day. To create a consistent data series, the average of the low and high prices for a trading day was used in this analysis[6].

The storage cost adjusted spread was close to full carry for the 1966-67 crop year. In other words, the July futures price nearly equaled the May futures price plus the cost of storage. The spread was most inverted in the 1963-64 crop year when the May futures price plus storage cost was 22 percent higher than the July futures price.

From the conceptual model, displacement of private stocks by public stocks is a function not only of the amount of public stocks but also of relationship between the public stocks release price and the market price and of the probability distribution of the market's expected price at time t+n. The price at which CCC-owned grain could be purchased was posted in the CCC monthly sales list. It was released at the end of a month for the forthcoming month. Thus, the CCC sales price for May was the information contemporaneous with the market's determination of price on the last trading day of April. CCC-owned stock acquired in May would have to be stored until July, implying that the effective CCC sales price for May needs to be adjusted for storage cost from May to July. Consequently, the relationship between the CCC sales price for May and the July futures price on the last trading day of April was calculated using a formula similar to that of Equation 9:

(10) Relationship between CCC May Sales Price and July Futures Price =
$\ln[CCCSP_t + (USTB_t \bullet CCCSP_t \bullet 0.1667) + (PS_t \bullet 0.1667)) - \ln(July_t)$
where,
$CCCSP_t$ = CCC sales price for May and the other variables are defined in Equation 9.

For all crop years, the storage cost adjusted CCC-sales price for May exceeded the July futures price, with the smallest difference being nine percent (1966-67 crop year).

An estimate of the market's expected price distribution is commonly derived using option premium. However, the trading of options on crops was banned between 1938 and 1984 (Board of Trade of the City of Chicago). An option premium is a function of the volatility of price, which is often measured using the standard deviation of the ln of daily price changes. To proxy the variance of the price distribution, the standard deviation was calculated for the ln change in the July Kansas City futures prices over the 40 trading days prior to and including the last trading day of April[7]. Because only low and high futures prices were available for the entire analysis period, the average of the standard deviation of these two price series for a given year was used. The standard deviation of the ln daily changes in price averaged 0.5 percent, with the largest value for an individual crop year being 1.5 percent (1966-67 crop year).

The 1964-65 and 1965-66 crop years were eliminated from the analysis. For 1964-65, no CCC sales price was available because CCC sales were suspended. It was not clear why sales were suspended. For 1965-66, a notable discrepancy existed between total CCC-owned stocks and uncommitted CCC-owned stocks on June 30. The former was 340 million bushels while the

latter was 262 million bushels, or 23 percent smaller. In contrast, for the five other crop years in which both measures were available, the largest difference was 6 percent (1964-65). It is not clear how to classify committed CCC stocks. While still stored with CCC, they have been sold to the private sector and thus could be classified as private stocks. Consequently, the decision was made to eliminate the 1965-66 crop year from the analysis. To maintain a consistent data set for CCC-owned stocks, total CCC-owned stocks were used for all crop years.

Empirical Results

Consistent with the conceptual model, the regression coefficients have their expected signs and are statistically significant at the 95 percent confidence level (see Table 2). Thus, *ceteris paribus*, the amount of private stocks decreases as the level of public stocks increases, the closer the market price is to the public stocks release price, and the greater the variation in market prices. Also, as expected from Working's price of storage model, private storage agents will carry more stocks the higher are the expected net returns to private storage, *ceteris paribus*.

Because there were only 17 observations, a bootstrap regression analysis was conducted. The bootstrap consisted of 500 random draws from the original data set. The share of the bootstrap coefficients with the same sign as the coefficient in the original regression exceeded 95 percent (see last column of Table 2). Thus, the bootstrap analysis also finds that the estimated coefficients for the independent variables have their hypothesized sign and are statistically significant at the 95 percent confidence level.

The coefficient on public stocks of -0.87 does not differ significantly from -1 (t-test equals 0.68). Thus, the displacement for the first unit of public stocks of wheat did not differ significantly from one during the period of this study.

The rate of displacement of private wheat stocks decreased as public stocks increased. The marginal displacement is presented in Figure 1 for levels of public stocks up to 100 percent of annual consumption. This is the level of public stocks at which the marginal displacement becomes zero.

Figure 1 also contains the net addition to total stocks (private plus public stocks). To calculate the net addition, the amount of private stocks is calculated at a given level of public stocks using the regression equation presented in Table 2 and the mean value for the three other independent variables. The calculated amount of private stocks is then added to the amount of public stocks. To illustrate the interpretation of this measure, accumulation of public stocks equal to 10 percent of annual consumption increases total stocks by only 1.8 percent of annual consumption.

The relationship in Figure 1 implies that to initially increase total stocks by an amount equal to 10 percent of annual use would require accumulating public stocks equal to 35 percent of annual use. However, because the marginal displacement of private stocks declines, to increase total stocks by another 10 percent of annual consumption would require further increasing public stocks by an amount equal to 20 percent, not 35 percent, of annual consumption.

Summary, Conclusions, and Implications

It is commonly-accepted that private storage agents will reduce the stocks they hold when public stocks exist. In contrast, empirical estimates of the displacement effect vary widely, ranging from no displacement to 100 percent displacement. Given the disconnect that exists between the commonly-accepted hypothesis and the existing empirical evidence; this study reexamined the displacement of private stocks by public stocks.

A conceptual model was developed utilizing the concept of options. The conceptual model implies that no displacement occurs when there is no probability that market price may exceed the public stock release price. Displacement begins not when public stocks are released but when the market assigns a positive probability to their potential release. Once the market assigns a positive probability to the release of public stocks, the displacement of private stocks by public stocks is greatest for the first unit of public stocks, then declines with each additional unit of public stocks. Displacement eventually reaches zero when public stocks are large enough to cover all shortfalls. In addition, *ceteris paribus*, the displacement effect of public stocks depends on the slope parameter of the commodity's demand equation, the probability distribution of price, and the relationship between market price and public stock release price.

An empirical investigation of this conceptual model was conducted for carryout stocks of U.S. wheat from the 1953-54 though 1971-72 crop years. Given the limited number of observations, the regression results were bootstrapped. Results of this empirical investigation are consistent with the conceptual model. Consistent with the conceptual model, the displacement effect decreased as the amount of public stocks increased. Zero displacement was reached when public stocks equaled 100 percent of annual consumption. The displacement effect of the first unit of U.S. wheat public stocks did not differ statistically from 100 percent.

The conceptual model and empirical results of this study imply that missing variables is one explanation for the wide range of empirical estimates by previous empirical studies of the displacement effect of public stocks on private stocks is missing variables. Specifically, previous studies did not examine a nonlinear displacement effect as well as the importance of the relationship between the public stock release price and the market price and the variability of market prices. However, the conceptual model also suggests that the displacement effect will vary by commodity as well as over time because the displacement effect depends in part on the slope parameter of the demand equation. It would be useful to empirically test the conceptual model across a given commodity in different countries and across different commodities.

While both the conceptual model and empirical analysis finds that the displacement of private stocks is a substantial cost of a public stock policy, it also suggests that the accumulation of public stocks can enhance total stocks. Thus, the policy decisions regarding public stocks are more interesting than if the displacement of private stocks by public stocks is either none or 100 percent. In short, the social, political, and economic impacts of public stocks may lead countries to decide that the accumulation of public stocks is an appropriate public policy option despite the sizeable costs associated with displacing private stocks.

References

Abbott, P.C., C. Hurt, and W. E. Tyner (July 2008). "What's Driving Food Prices?" Farm Foundation Issue Report. Accessed September 15, 2011 at http://www.farmfoundation.org/news/articlefiles/404-FINAL%20WDFP%20REPORT%207-28-08.pdf

Abbott, P.C., C. Hurt, and W. E. Tyner (July 2011). "What's Driving Food Prices in 2011?" Farm Foundation Issue Report. Accessed September 15, 2011 at http://www.farmfoundation.org/news/articlefiles/1742-FoodPrices_web.pdf

Board of Trade of the City of Chicago (1989). *Commodity Trading Manual*.

Board of Trade of Kansas City, Mo. (1954-1972). *Annual Statistical Report*.

The Economist (April 19, 2008). "The Silent Tsunami – the food crisis and how to solve it." 387: 13.

Federal Reserve Bank of St. Louis (2011). *Treasury Bills.* Accessed on December 22, 2011 at http://research.stlouisfed.org/fred2/categories/116/downloaddata

Gardner, B. (June 1981). "Farmer-Owned Grain Reserve Program Needs Modification to Improve Effectiveness: Consequences of USDA's Farmer-Owned Reserve Program for Grain Stocks and Prices." *Report to the Congress*. The U.S. General Accounting Office CED-81-70. Volume 2.

Just, R. (June 1981). "Farmer-Owned Grain Reserve Program Needs Modification to Improve Effectiveness: Theoretical and Empirical Considerations in Agricultural Buffer Stock Policy Under the *Food and Agriculture Act of 1977*." *Report to the Congress*. The U.S. General Accounting Office CED-81-70. Volume 3.

Kenyon, D., E. Jones, and A. McGuirk (May 1993). "Forecasting Performance of Corn and Soybean Harvest Futures Contracts." *American Journal of Agricultural Economics*, 75: 399-407. Retrieved February 25, 2011 from JSTOR at http://www.jstor.org/stable/1242924.

Miranda, M. J. and P. G. Helmberger (1988). "The Effects of Commodity Price Stabilization Programs." *American Economic Review*. 78: 46-58.

Organization for Economic Co-Operation and Development (August 2008). "Rising Agricultural Prices: Causes, Consequences and Responses." *Policy Brief*. Accessed July 8, 2009 at http://www.oecd.org/dataoecd/1/36/41227216.pdf.

Peck, A. (1977-78). "Implications of Private Storage of Grains for Buffer Stock Schemes to Stabilize Prices." *Food Research Institute Studies*. Stanford University, Food Research Institute. 16, Number 3: 125-140.

Routledge, B. R., D. J. Seppi, and C. S. Spatt (2000). "Equilibrium Forward Curves for Commodities." *Journal of Finance*. 55: 1297-1338.

Schaffer, H. D., C. Hellwinckel, D. E. Ray, and D. G. De La Torre Ugarte (September 10, 2011). "A Study of the Impact of a Reserve Program Had One Been in Effect in the Period, 1998 to 2010." Agricultural Policy Analysis Center, Department of Agricultural and Resource Economics, University of Tennessee Institute of Agriculture. Knoxville, Tennessee. Accessed October 3, 2011 at http://www.nfu.org/images/stories/policy/091211_Report.pdf

Sharples, J. A. and F. D. Holland (August 1981). "Impact of the Farmer-Owned Reserve on Privately Owned Wheat Stocks." *American Journal of Agricultural Economics*. 63: 538-543.

Trostle, R. (May 2008, revised July 2008). *Global Agricultural Supply and Demand: Factors Contributing to the Recent Increase in Food Commodity Prices*. U.S. Department of Agriculture, Economic Research Service WRS-0801. Accessed June 24, 2009 at http://www.icpf.cas.cz/kaim/TISKY/WRS0801.pdf.

von Braun, J. with A. Ahmed, K. Asenso-Okyere, S. Fan, A. Gulati, J. Hoddinott, R. Pandya-Lorch, M. W. Rosegrant, M. Ruel, M. Torero, T. van Rheenen, and K. von Grebmer (May 2008). "High Food Prices: The What, Who, and How of Proposed Policy Actions." International Food Policy Research Institute. Accessed June 24, 2009 at http://www.ifpri.org/PUBS/ib/foodprices.asp.

U.S. Department of Agriculture (USDA). (various issues, 1960-1977). *Agricultural Statistics*. U.S. Government Printing Office.

U.S. Department of Agriculture (USDA), Commodity Credit Corporation (CCC). (1954-1972). *Monthly Sales List, May*.

U.S. Department of Agriculture (USDA), Economic Research Service (September 1996). *Provisions of the Federal Agriculture Improvement and Reform Act of 1996*. Edited by F. Nelson and L. Schertz. Agriculture Information Bulletin No. 729.

U.S. General Services Administration, National Archives and Records Service, Office of the Federal Register (various issues, 1954-1972). *Federal Register*.

Working, H. (February 1934) "Price Relations between May and New-Crop Wheat Futures at Chicago Since 1885." *Wheat Studies*. Stanford University, Food Research Institute. 10: 183-228.

Working, H. (1948). "Theory of the Inverse Carrying Charge in Futures Markets." *Journal of Farm Economics*. 30: 1-28.

Working, H. (1949). "The Theory of Price of Storage." *American Economic Review*. 39: 1254-1262.

Endnotes

[1] The supply and demand factors most commonly-mentioned are (1) world-wide growth in income and associated demand for food; (2) increased use of farm commodities for biofuels, including government mandated use of biofuels; (3) lack of public investment in agricultural research; (4) reduced production of crops, especially rice and wheat, due to inclement weather and other factors; (5) increasing costs of farm inputs, notably energy-based inputs; and (6) restrictions on exports of farm commodities by several important exporting counties in response to concerns about domestic food scarcity.

[2] Under the Farmer-Owned Reserve (FOR) program, U.S. farmers held grain under a government loan for up to three years. Famers also received a public storage subsidy. The grain could not be sold until market price exceeded a pre-specified release price. Thus, while not owned by the government, FOR stocks served a public stocks role.

[3] Because the conceptual model suggests the displacement effect could vary by commodity, analysis of U.S. corn and soybean carryout stocks was considered. A concern with analyzing corn carryout stocks is that, over the 1953-54 through 1971-72 crop years, the other feed grains were substantial. For example, in the 1971-72 crop years, acres of barley, oats, and sorghum harvested for grain totaled 42.0 million while acres of corn harvested for grain totaled 74.2 million (USDA, *Agricultural Statistics*). While barley, oats, and sorghum compete with corn, the exact substitution effects depend upon a complex interplay of variables, including feed values and relative prices. These interactions are difficult to model, especially in an annual model. For soybeans, the estimated model was unstable, both in terms of the numerical value and statistical significance of the regression coefficients. In particular, the carryout data for the 1968-69 crop year was suspect since the sum of private stocks and CCC-owned stocks exceeded total stocks as reported by USDA. In addition, not only was the share of total carryout stocks that were public stocks the higher for the 1968-69 crop year but its public stock share was more than 3 times higher than for any other crop year except 1969-70. In short, 1968-69 was an influential outlier with questionable data.

[4] The difference between total carryout stocks and grain owned by the Commodity Credit Corporation (CCC) includes stocks held under loan. Grain under loan was held by farmers as collateral against CCC nonrecourse loans. Carryout loan grain could be grain harvested in the just completed crop year or in prior years. The latter grain under loan was called resealed gain. Farmers could reacquire loan grain by repaying the original loan rate minus any physical storage charges deducted by CCC plus interest accumulated since the loan was made (U.S. General Services Administration). The CCC sales price for Kansas City averaged 5.6 percent higher than the loan rate for Kansas City over the 1953-54 through 1964-65 crop years and 14.6 percent higher than the Kansas City loan rate over the 1967-68 through 1971-72 crop years. Nevertheless, it was possible that resealed grain could have a repayment loan rate that exceeded the current year's CCC sales price if the loan rate declined, especially if the decline was notable. By far, the largest reduction in the U.S. average loan rate over the analysis period was from $1.82 for the 1963-64 crop year to $1.30 for the 1964-65 crop year. However, the 1964-65 crop year was excluded from the analysis because of missing data for the CCC sale price. The 1965-66 crop year also was eliminated because of concerns over data. Thus, the two years most

affected by declines in the loan rate were eliminated from the analysis for other reasons. In addition, as a sensitivity test, private stocks were reduced and public stocks increased by any grain under loan whose associated loan rate exceeded the CCC sales price. This adjustment did not change the statistical significance of the independent variables. This result was not surprising since the number of bushels involved never exceeded 26 million bushels.

[5] R^2 was 0.890 when annual consumption was used and 0.905 when consumption during the last quarter of the crop year was used. While R^2 increased by only 0.015, the increase was 13 percent of the unexplained variance.

[6] For the 1966 and later observations, the largest difference between the May-July spread calculated using the average of the low and high prices versus the closing prices for April 30 was 0.375 cents per bushel. Thus, during this study's analysis period, the difference between these two measure of the spread was relatively little.

[7] Price variability was also calculated for the 20 and 30 trading days prior to and including the last trading day of April. The correlation between price variability for 20 and 40 days and for 30 and 40 days was +0.94 and +0.99, respectively. The alternative measures of price variability did not change the statistical significance of the coefficients.

TABLE 1: Descriptive Statistics for Variables Used to Examine Displacement of Private Carryout Stocks by Public Carryout Stocks, U.S. Wheat, 1953 – 1971 Crop Years[A,B]

Variable	Mean	Standard Deviation	Minimum	Maximum
Ratio of private stocks to annualized consumption during last quarter of crop year	0.206	0.154	0.047	0.558
Ratio of CCC-owned stocks to annualized consumption during last quarter of crop year	0.678	0.402	0.085	1.207
ln difference between storage-cost adjusted May CCC Sales Price and July futures price	-0.262	0.084	-0.388	-0.090
Standard deviation of ln change in daily July futures price for 40 days prior to April 30	0.005	0.003	0.001	0.015
ln difference between July futures price and storage-cost adjusted May futures price	-0.074	0.056	-0.221	-0.001

NOTES: (A) Both the 1964-65 and 1965-66 crop years were excluded from the analysis for reasons discussed in the text. (B) Over the analysis period, the U.S. wheat crop year was from July 1 through June 30.

SOURCE: original calculations

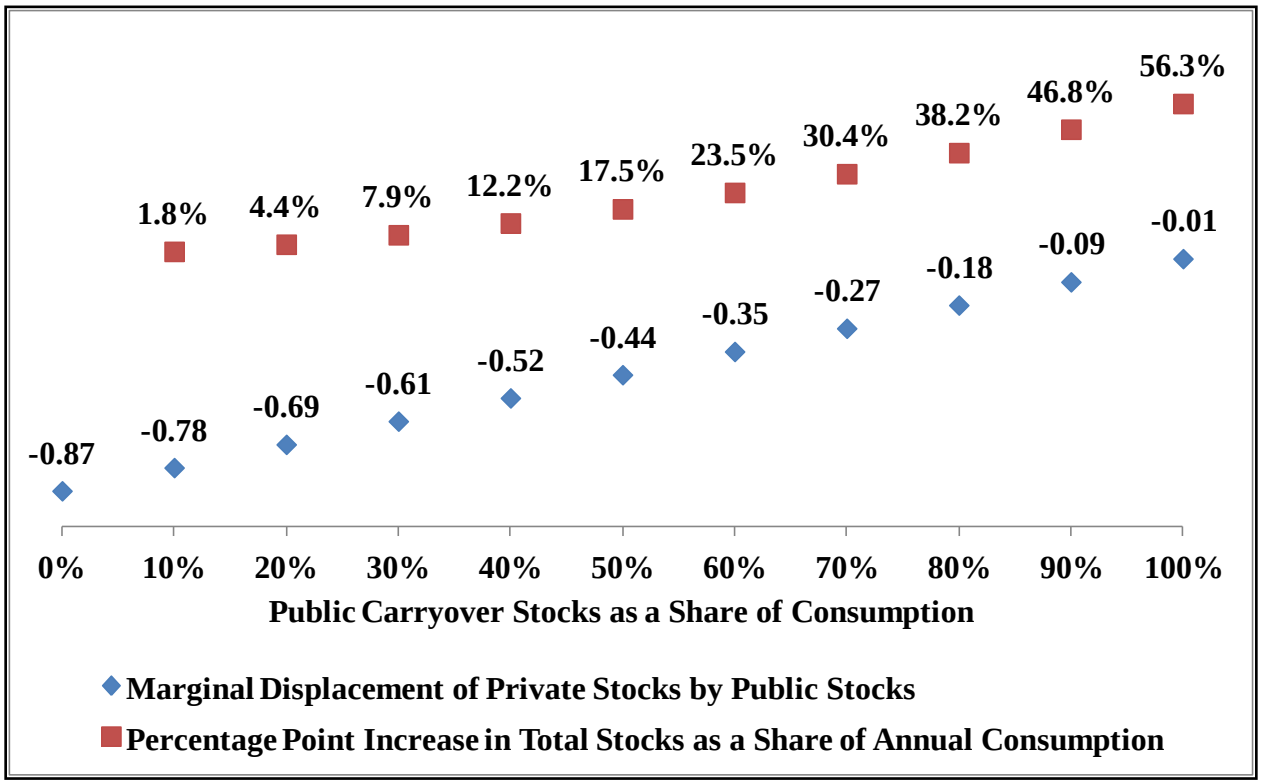
TABLE 2: Regression Results for Displacement of Private Carryout Stocks by Public Carryout Stocks, U.S. Wheat, 1953 – 1971 Crop Years[A,B, C]

Independent Variable	Regression Analysis of Original Data			Bootstrap
	Coefficient	Standard Error	t-test	Share of Coefficients[E]
Intercept	0.55	0.09	5.98[D]	99.60%
Ratio of CCC-owned stocks to annualized consumption during last quarter of crop year	-0.87	0.19	-4.56[D]	100.00%
Square of ratio of CCC-owned stocks to annualized consumption during last quarter of crop year	0.43	0.14	3.03[D]	99.00%
ln difference between July futures price and storage-cost adjusted May CCC Sales Price	-0.63	0.25	-2.45[D]	95.60%
Standard deviation of ln changes in daily July futures price for 40 days prior to April 30	-17.44	5.85	-2.98[D]	97.00%
ln difference between July futures price and storage-cost adjusted May futures price	1.24	0.40	3.08[D]	98.40%
R^2: 0.905 Number of Observations: 17				

NOTES: (A) Public stocks are stocks owned by the Commodity Credit Corporation at the end of a crop year. (B) Both the 1964-65 and 1965-66 crop years were excluded from the analysis for reasons discussed in the text. (C) Over the analysis period, the U.S. wheat crop year was from July 1 through June 30. (D) Coefficient is statistically significant at the 5% test level for a two-tail test for the intercept and for a one-tail test for all other variables. (E) Share of 500 bootstrap regression coefficients that have the same sign as the coefficient in the regression using the original data.

SOURCE: original calculations

FIGURE 1: Marginal Displacement of Private Stocks by Public Stocks and Net Addition to Total Stocks (Private[A] + Public) by Amount of Public Stocks, Wheat Carryout Stocks, U.S., 1953-1971 Crop Years[B,C]



NOTES: (A) Private stocks are calculated using the regression equation presented in Table 2, with the independent variables, expect for public stocks, measured at their mean value for the analysis period. (B) Both the 1964-65 and 1965-66 crop years were excluded from the analysis for reasons discussed in the text. (C) Over the analysis period, the U.S. wheat crop year was from July 1 through June 30.

SOURCE: original calculations