Soybeans - Marketing

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# ESTIMATES OF THE PRICE OF STORAGE IN FUTURES MARKETS FOR SOYBEANS, CORN AND OATS

by

Paul A. Anderson and Paul L. Farris

Intertemporal price differences in futures markets affect commodity storage decisions, production plans and hedging programs. Changes in futures price differences may thereby influence current and future market supplies. Futures market price spreads, in turn, are influenced by storage costs and commodity demands.

Holbrook Working developed a price of storage theory to explain intertemporal price spreads for storable, seasonally produced commodities (8, 9, 10). The price of storage is defined as the difference between any futures price and the current cash quotation, or the difference between a distant and a nearby futures price. Components of the price of storage are physical costs of storage for the time interval minus a convenience yield.

The convenience yield arises from indirect benefits of having inventories available for a variety of current operating purposes. When supplies are abundant, price spreads mainly reflect storage costs. But when current stocks are scarce, convenience yields cause spot or near futures prices to rise relative to distant futures prices, and the market determined price of storage declines and frequently becomes negative.

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Paul A. Anderson is with Cargill Investor Services, Inc., Chicago, Illinois and Paul L. Farris is Professor of Agricultural Economics, Purdue University. This paper was prepared for presentation at the annual meeting of the American Agricultural Economics Association in Edmonton, Alberta, Canada, August 11-14, 1973.

Changes in expectations about the future are imparted equally to the entire temporal constellation of prices (4). Working's empirical studies for wheat and Telser's analyses for wheat and cotton supported the price of storage theory (3, 7).

In this study, intertemporal futures price spreads for corn, soybeans and oats were examined, using a relative scarcity variable, to determine whether differences in price spreads were consistent with the price of storage theory. An expectations variable was then introduced into the analysis for each commodity. The results, in brief, were consistent with the price of storage theory. Measures of changes in expectations did not provide added significance to the explanation provided by the relative scarcity variable. This supports the point of view that changes in expectations affect all temporal prices equally.

## Empirical Analysis

The model

$$y = a - \frac{b}{x}$$

was employed, where y = the price of storage and x = a relative scarcity measure of stocks (1). The constant, a, reflects physical costs of storage at the theoretical limit when stocks are so large that the convenience yield is zero.

### Soybeans

The years selected were 1956-1971. The January minus September futures price spread as of September 7 was used as the price of storage. On this date, current stocks are typically relatively low.

The measure of stocks was the visible supply of soybeans in the United States on or around September 1, as compiled by the Chicago

Board of Trade. This statistic is an estimate of soybean stocks in warehouses at prominent grain centers east of the Rocky Mountains, plus quantities afloat on the Great Lakes (2). The visible supply was divided by the total supply of soybeans as of September 1, the preceeding year to obtain a relative scarcity measure.

The results of the analysis appear in Table 1, Equation 1. Owing to the fact that 1969 appeared to be an unusual year, Equation 2 was run without the 1969 observation. A dock strike in 1969 boosted the visible supply statistic. Traders were aware that part of the visible supplies were not available for normal operating purposes. Figure 1 shows the data and relationships with and without the 1969 observation.

An analysis was also made relating the May minus January price spread as of January 15 to relative scarcity of soybeans on January 1, but insignificant results were obtained.

<u>Corn</u>

Available information and a relatively stable production and merchandising pattern enabled use of the 1947-71 period for corn. Several spreads were examined to ascertain the effects of relative scarcity of stocks on the price of storage within crop years, between crop years and for time intervals of different lengths. The stock figure was from the USDA report of quarterly stocks in all positions (5).

The first equation relates the price of storage between March and July to the relative scarcity of inventories on January 1. A time correspondence problem lies in the fact that the July-March spread should measure reaction to inventories on March 1. But the problem

Table 1. Regression estimates of relations between relative scarcity of soybeans on September 1 and January minus September futures price spread as of September 7.

| | Equation Number | |
|---|---|---|
| | (1) | (2) |
| Number of Observations | 16 | 15 |
| $r^2$ | .310 | .694 |
| a | 5.702 | 8.727 |
| ~~$\frac{1}{x}$~~ b | -.030<br>(2.51) | -.044<br>(5.43) |

(t values in parentheses)

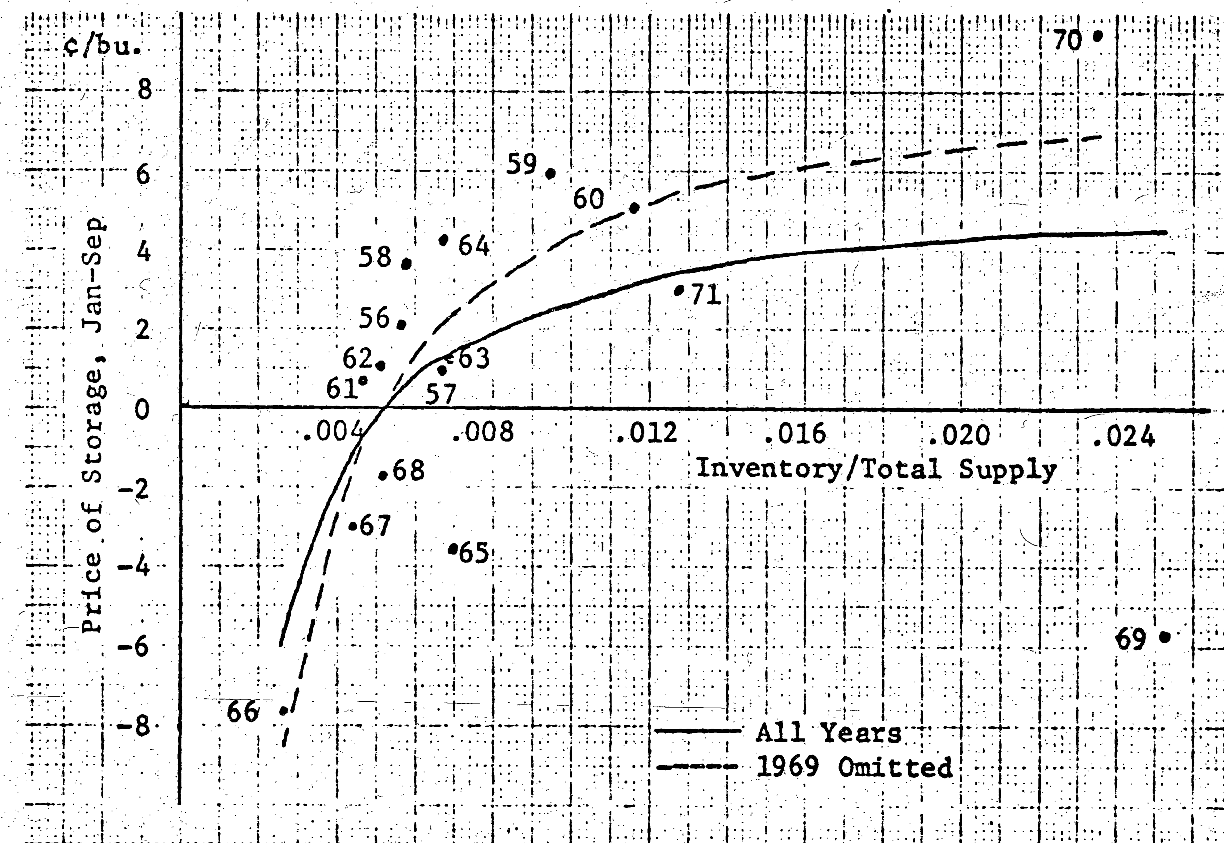


Figure 1. Price of Storage, September to January, Related to Relative Scarcity of Inventories, for Soybean Futures(195 -1971).

is not particularly serious because the January statistic provides a fairly good estimate of the relative scarcity that will exist in March. There is also no way of alleviating this problem, since no corn futures contract expires in January. The July-March price of storage is taken on February 1, which gives the market time to assimilate the stocks report (historically released between January 11 and 22).

Consumption to January 1 is defined as total supply for the crop year (starting the previous October 1) minus stocks on January 1 (all inventories, on and off farms). The years 1948, 49, 52, 54, and 56 were omitted from the regression because price data were not available for the March option. The results are shown in Equation 3, Table 2 and Figure 2.

Another within crop year spread in corn is the September minus May futures price calculated on May 1. Relative scarcity is for April 1, computed in exactly the same manner as before, but using the April stocks in all positions. All years were included. The results of this regression are in Equation 4 and Figure 3.

Yet another within crop year spread is the September minus July price of storage as of mid-July. These results appear in Equation 5 and Figure 4.

The old-new crop spread used for corn was the December minus the September futures price taken on August 1 and related to July 1 stocks. The results for this analysis are in Equation 6 and Figure 5. They indicate that the convenience yield toward the end of the crop year is large relative to physical carrying costs, particularly for the relatively short storage period from September to December. Taking a longer period, from September to May, for the price of storage as of August 1, and the same relative scarcity variable, as of July 1, as in Equation 6, the curve was shifted upward (Equation 7 and Figure 6), indicating higher physical carrying costs over this longer storage period.

Table 2. Regression estimates of relations between relative scarcity of corn and futures price spreads for corn, 1947-71.

| | Equation number | | | | |
|---|---|---|---|---|---|
| | (3) | (4) | (5) | (6) | (7) |
| Number of observations | 19[1] | 25 | 25 | 25 | 25 |
| Dependent variable | July minus March futures price on Feb. 1 | Sept. minus May futures price on May 1 | Sept. minus July futures price on July 16 | Dec. minus Sept. futures price on Aug. 1 | May minus Sept. futures price on August 1 |
| $r^2$ | .598 | .704 | .772 | .410 | .433 |
| a | 11.505 | 15.000 | 9.229 | 1.012 | 9.917 |
| Independent variables, reciprocal of relative scarcity on | | | | | |
| January 1 | -25.277<br>(5.02) | | | | |
| April 1 | | -18.933<br>(7.40) | | | |
| July 1 | | | -7.469<br>(8.83) | -3.794<br>(4.00) | -5.541<br>(4.19) |

[1] Observations excluded for 1948, 49, 52, 53, 54, and 56.

(t values in parentheses)

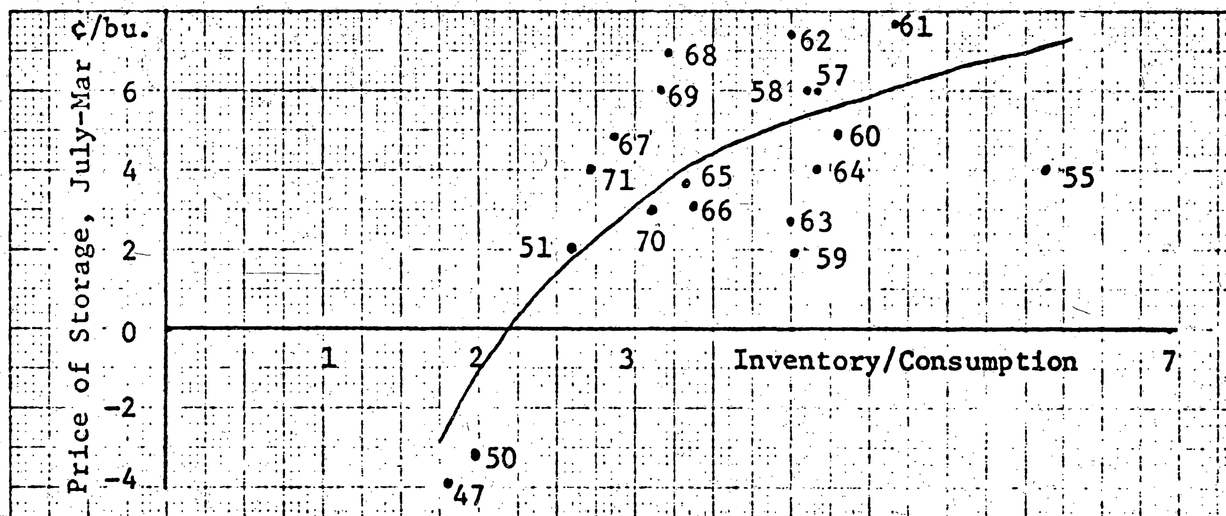


Figure 2. Price of Storage, March to July, Related to Relative Scarcity of Inventories, for Corn Futures (1947-1971, excluding 1948, 1949, 1952, 1953, 1954, 1956.

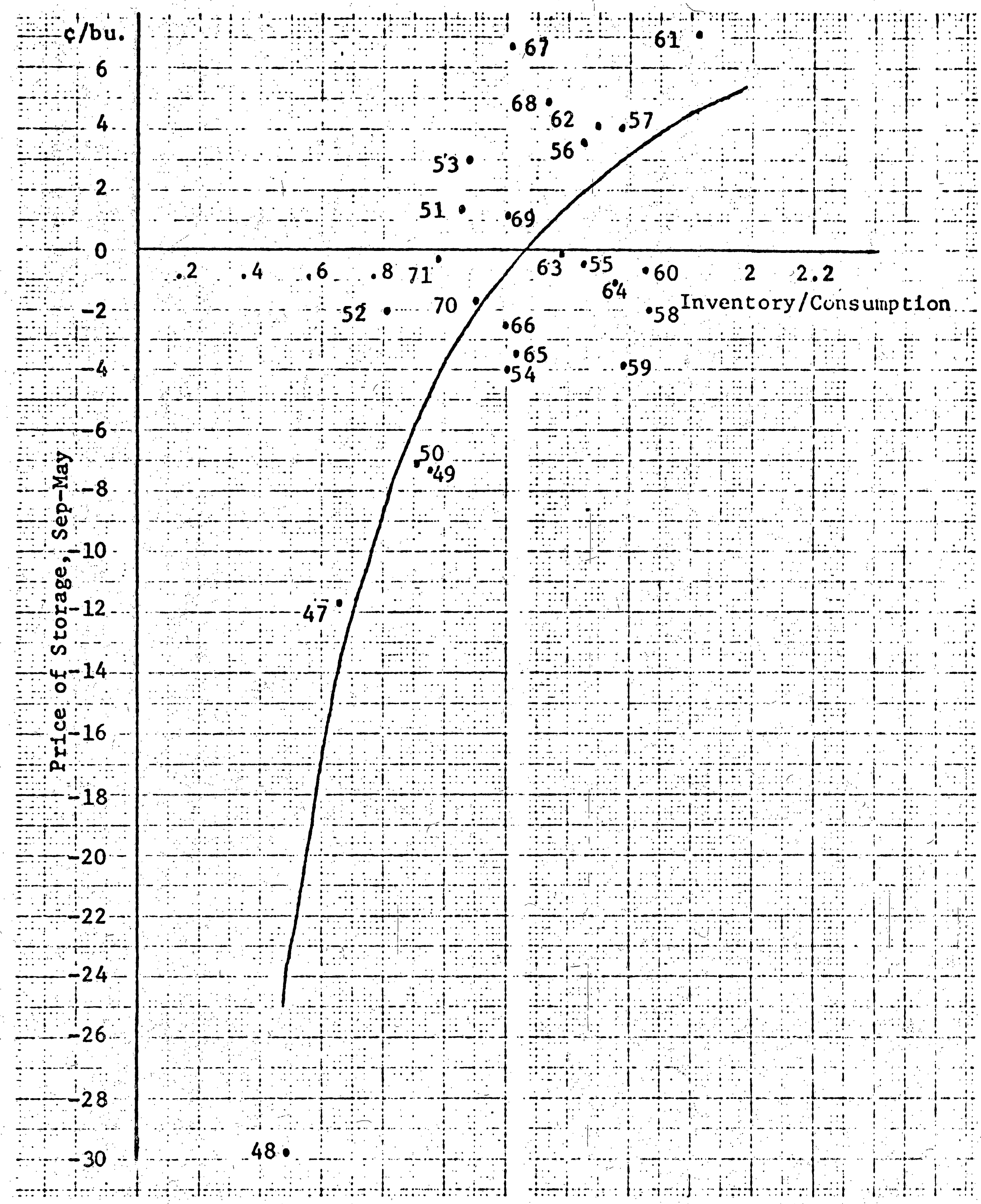


Figure 3. Price of Storage, May to September, Related to Relative Scarcity of Inventories, for Corn Futures(1947-1971).

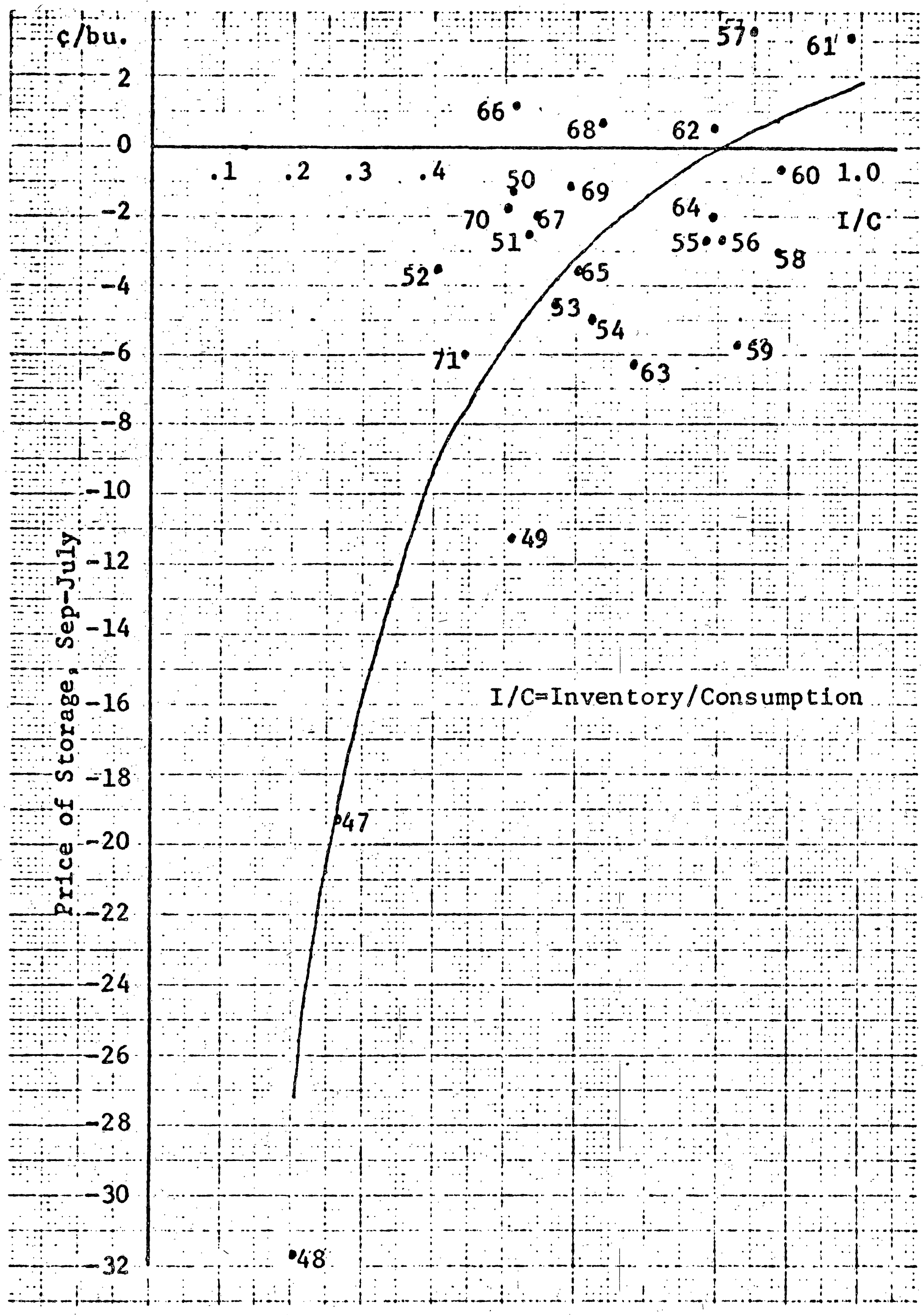


Figure 4. Price of Storage, July to September, Related to Relative Scarcity of Inventories, for Corn Futures(1947-1971).

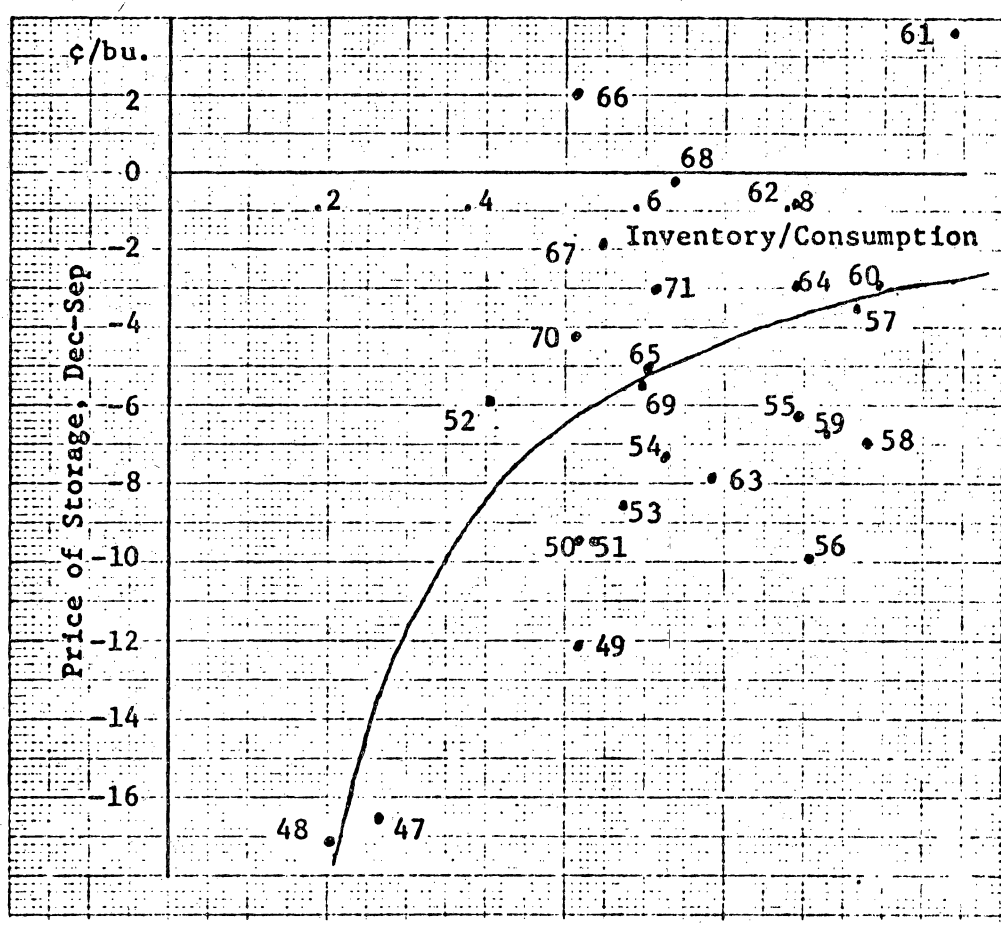


Figure 5. Price of Storage, September to December, Related to Relative Scarcity of Inventories, for Corn Futures (1947-1971).

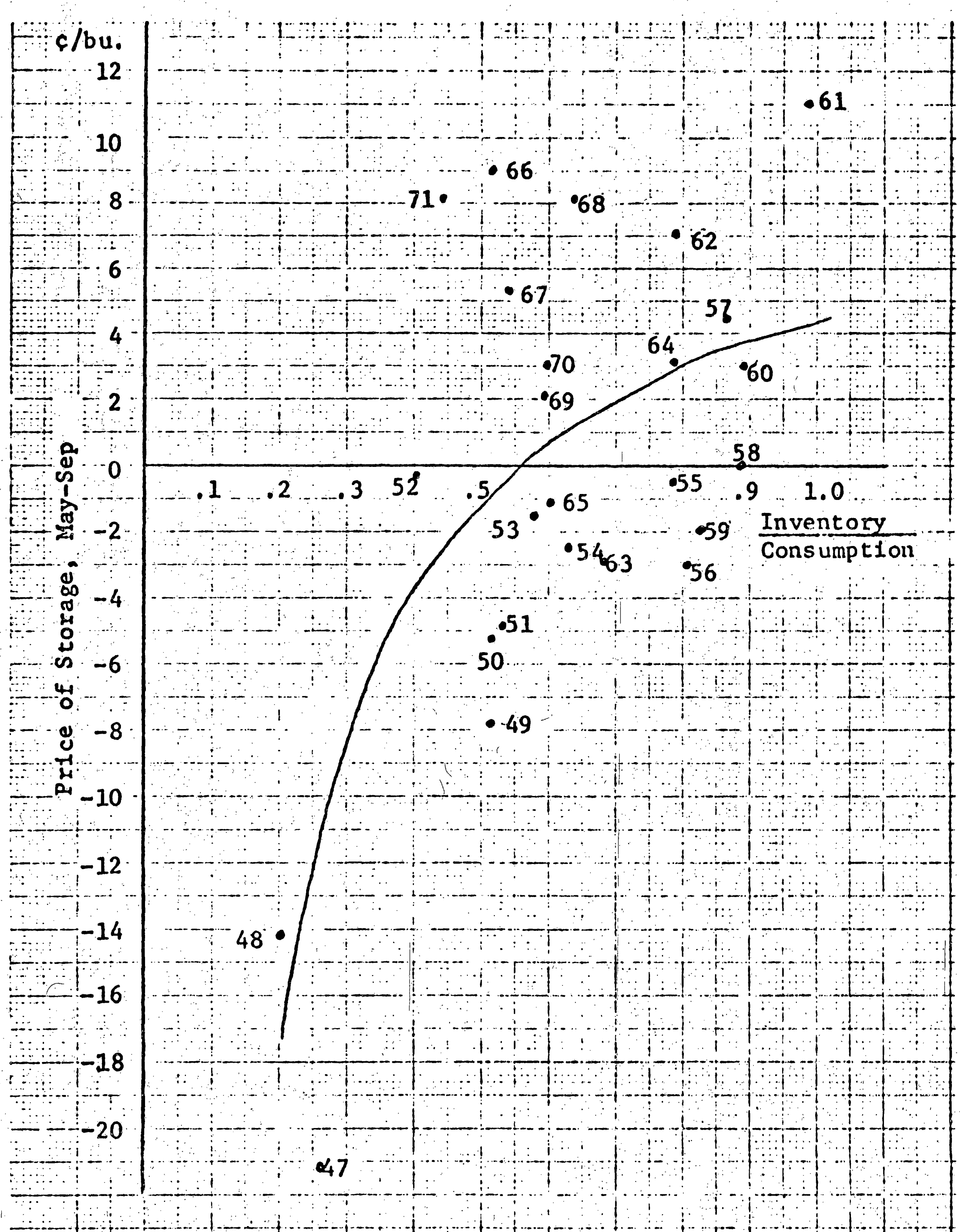


Figure 6. Price of Storage, September to May, Related to Relative Scarcity of Inventories, for Corn Futures (1947-1971).

Oats

The period selected for oats was 1945-1962. Production showed no time trend during this period, which facilitated later analysis in which the crop production variable, as a measure of expectations, was incorporated.

The spread chosen for oats was the December minus July futures price difference on July 16. This can generally be considered an old-new crop spread, although the crop year for oats begins in July. The major marketing of oats usually takes place in August. No crop reports are available for oats until July because it is a relatively minor crop. The relative scarcity variable was stocks of oats in all positions on July 1 divided by total consumption to July 1. Consumption was defined as total stocks of oats for the previous crop year (beginning the previous July 1) minus July 1 stocks in all positions. The regression equation estimated was as follows:

$$(8) \quad \hat{Y} = 13.136 - \underset{(2.91)}{2.515} \left(\frac{1}{x}\right) \; ; \; r^2 = .345.$$

Figure 7 presents the results.

Summary of Results

The evidence presented for soybeans, corn, and oats show that temporal price spreads for these storable, annually produced commodities conform to Working's theoretical price of storage curve. The coefficients of the relative scarcity variables are all statistically significant, and the signs are consistent with a priori expectations.

However, the results show some lack of precision, which may be due to a number of reasons:

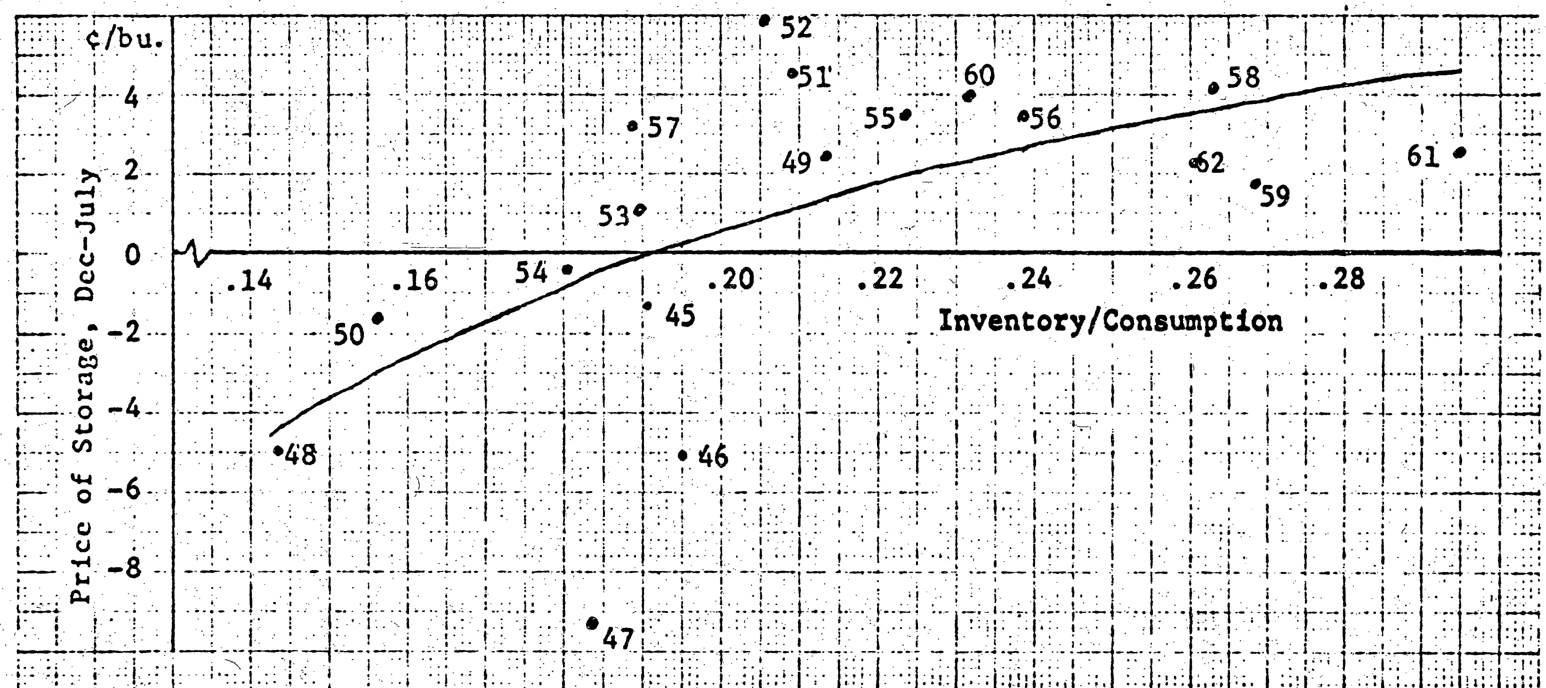


Figure 7. Price of Storage, July to December, Related to Relative Scarcity of Inventories, for Oats Futures(1945-1962).

1. The role of expectations, as discussed in the next section, was omitted.
2. Two of the data sets, soybeans and oats, were taken within maturation months, when erratic price movements sometimes occurred.
3. Correspondence problems existed, not only of time, but of finding the "right" estimate for the level of stocks.
4. The functional form used may not have been optimal.
5. Other "present" factors may have affected the price of storage. In particular, the physical price of storage depends, to an extent, on the amount of other grain competing for the same storage space.

## The Role of Expectations

It has been suggested that future expectations affect the price of storage (6). USDA crop production estimates were used as indicators of expectations. Variables incorporating crop production estimates were entered into regressions presented in the preceeding sections.

### Soybeans

Production of soybeans has grown in a linear fashion since 1956, which necessitates arriving at a figure for the August crop estimate that can be viewed as over or under the yearly trend. Therefore, the yearly trend in August soybean production estimates since 1956 was estimated using ordinary least squares ($r^2 = .976$). The deviations from the calculated regression line were used as the measure of expectations. Adding this variable to soybean equation (1) did not add significantly to the explained variance.

Corn

Corn production has likewise grown over the period 1947-1971, though not in as close a linear fashion as soybeans ($r^2$ = .700 for the relation between time and the July corn production estimate.) As with soybeans, the deviations were used as indications of changes in expectations. This variable was added to the corn equation 6. Again no significant increase in explained variation appeared.

Oats

For oats production, which showed no trend during 1945-62, the July production estimate was used as the measure of expectations and entered into the oats regression equation developed in the preceeding section. Again the added variable did not add significantly to the explained variation.

Summary of Results Incorporating a Variable for Expectations

The regressions for corn, oats, and soybeans provide no evidence that crop production estimates have any effect on old-new crop spreads. Alternative formulations and transformations incorporating crop production estimates as measures of expectations likewise led to the same conclusion.

## Summary and Conclusions

Working's price of storage theory was tested using corn, soybeans, and oats. A single equation least squares model was employed using a functional form which approximated the theoretical form. The price of storage was related to the current relative scarcity of inventories. Results were consistent with theoretical expectations.

It has also been suggested that the price of storage should allow for expected inventory behavior during the time interval covered.

Old-new crop price spreads were examined to determine whether inclusion of new crop production estimates as indications of changes in future expectations were significantly related to the price of storage. A multiple regression model was employed in which a variable reflecting new crop production estimates, along with scarcity of inventories, was related to the price of storage. The expectations variable did not add significance to the statistical explanation given by the relative scarcity variable.

This study indicates that differences in futures prices for corn, soybeans, and oats reflect physical costs of storing between periods and indirect benefits derived from holding inventories. Further research is needed to determine whether futures price differences for commodities which may be neither storable nor seasonally produced behave in accordance with the price of storage theory. Further study is also needed to ascertain whether particular components of the convenience yield can be identified and measured.

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