Is Storage at a Loss Merely an Illusion of Aggregation?

Jason R.V. Franken,

Philip Garcia,

and

Scott H. Irwin*

Paper presented at the NCCC-134 Conference on Applied Commodity Price Analysis, Forecasting, and Market Risk Management St. Louis, Missouri, April 17-18, 2006

* Franken is a graduate student (*jrfranke@uiuc.edu*), Garcia is Professor and the T.A. Hieronymus Chair, and Irwin is the L.J. Norton Professor of Agricultural Marketing in the Department of Agricultural & Consumer Economics at the University of Illinois at Urbana-Champaign.

Is Storage at a Loss Merely an Illusion of Aggregation?

The storage at a loss paradox of positive inventories despite inadequate spot-futures price spread coverage of storage costs is an unresolved issue of long-standing interest to economists. Alternative explanations include risk premiums for futures market speculators, convenience yields from having inventories on hand, and the mismeasurement/aggregation of data. T-test analyses of disaggregated data suggest soybean price behavior consistent with intertemporal arbitrage conditions and corn price behavior that may imply convenience yields.

Key words: backwardation, storage at a loss, convenience yield, illusion of aggregation

Introduction

Seasonal production and geographically-dispersed agricultural commodity markets imply that temporal and spatial dimensions are relevant to storage decisions. When and where to store is of chief concern to those involved in the production, processing and marketing of storable commodities, and to policymakers overseeing market performance. Empirical anomalies of positive inventories despite inadequate futures-spot price spread coverage of storage costs (i.e., warehousing plus interest opportunity costs) appear to violate intertemporal arbitrage conditions. What causes the *storage at a loss paradox* is an unresolved issue of long-standing interest to economists.

As an alternative to conventional explanations, i.e., risk premiums (Keynes, 1930) and convenience yields (Kaldor, 1939; Working, 1948, 1949), some researchers (Wright and Williams, 1989; Benirschka and Binkley, 1995; Brennan, Williams, and Wright, 1997) suggest that data aggregation may produce the empirical anomalies.[1] Such findings would cease with precise definition of inventories and prices, given that similar, yet economically distinct, commodities are often reported in the same data category, though they differ by time-varying costs of transformation (e.g., transportation, processing, and merchandising).[2] Notably, Benirschka and Binkley (1995) dismiss alternative explanations, claiming instead that all empirical deviations from the theory of storage can be remedied by disaggregating the data:

> (T)he 'storage at a loss' paradox is no paradox at all. By discouraging storage where (interest opportunity) costs are relatively high, it provides the mechanism whereby the market brings about efficient stockholding over space and time (p. 523).

---

[1] Risk premiums, compensation for futures market speculators bearing risk, may downwardly bias futures prices as estimates of expected spot prices, making storage appear unprofitable. A convenience yield is an inventory's inherent replacement value, a consequence of costly short-run inflexibilities in transporting, processing, and trading commodities, which may offset apparent losses from storage.

[2] Wright and Williams (1989) offer several examples of related, but economically distinct, commodities; the same grade of wheat at two different elevators, dirty and clean corn at the same elevator, and certified and uncertified stocks of coffee. There is a trade-off between transforming the currently abundant commodity into the currently scarce commodity, and retaining inventories of the abundant commodity, as it may become scarce in the subsequent period.

However, like many studies on storage at a loss, Benirschka and Binkley's (1995) was hampered by a paucity of quality data. Further, their variable of primary interest (producer price received) was often insignificant, and the authors were able to offer only indirect empirical evidence in support of their theory of optimal storage.

This research employs a unique dataset to investigate the existence of *price growth-interest rate relationships* that, in conjunction with transportation costs, drive Benirschka and Binkley's (1995) theoretical model of optimal storage. More generally, this research addresses whether the returns from holding commodities and financial assets are in fact equal. Two implications of Benirschka and Binkley's (1995) findings are tested for Illinois corn and soybean spot markets over crop years 1973 through 2001.

First, Benirschka and Binkley's (1995) claim that spot prices grow faster further from the central market, the Gulf of Mexico, is assessed using pairwise t-tests of north-south mean differences in price growth net of physical storage costs. Their argument is that higher transportation costs reduce commodity prices, and hence the interest opportunity costs of storage, at distant locations. Consequently, nearby locations deliver the commodity to the central market earlier than distant locations.[3] Significantly faster (slower) relative price growth at a northern location supports (contradicts) Benirschka and Binkley's (1995) notion that interest opportunity costs explain spatial price growth differences.

Second, we consider Benirschka and Binkley's (1995) assertion that spot price growth must exactly cover the interest opportunity costs of storage where inventories are held.[4] The validity of this intertemporal arbitrage condition is assessed using pairwise t-tests of mean differences between price growth net of physical storage costs and three-month Treasury bill annual interest rates. Based on this assertion and the fact that corn and soybean inventories are continuously held across Illinois, price growth should consistently equal the interest rate.

Though expectations and not realized prices govern storage behavior, a lack of transportation cost data and a desire to test differences in price growth across locations necessitate substitution of spot prices for futures prices in our analysis. An implied assumption of our empirical framework is that if futures prices, as unbiased predictors of future spot prices, cover storage costs, then so too should spot prices on average. As Benirschka and Binkley (1995) also utilized spot prices in their empirical analysis, our work is directly comparable.

Higher volatility in commodity spot price growth relative to interest rates (Figures 1 and 2) calls into question the *price growth-interest rate relationships* suggested by Benirschka and Binkley (1995). Soybean price growth from harvest exceeds interest rates only in certain periods, while that of corn never attains such levels.

---

[3] Also northern locations in U.S. corn and soybean markets receive lower harvest prices, because harvest occurs later than in more southern locations. In corn, not only does this translate into a comparative advantage for storage in northern locations in terms of interest charges, but also in terms of shrink charges. Hence, producers at southern locations sell before prices hit harvest lows with completion of harvest at northern locations. At such depressed prices, producers in northern locations elect to store some portion of the crop, anticipating price to appreciate.

[4] In frictionless (i.e., zero transaction cost) markets, returns on commodity inventories (i.e. price growth net of physical storage costs) equal those on financial assets (Benirschka and Binkley, 1995). Departures from this are arbitrage opportunities, exploitation of which continues until the rates of return are equalized.

Literature Review

Researchers posit several explanations for the existence of inventories when markets are in backwardation.[5] Evidence from existing research is limited by a paucity of quality data, especially on inventories and prices at their locations, which led to the prevalent use of market-level and government prices and aggregated inventories or proxies. Keynes' (1930) risk premiums only account for instances when the observed loss from storage is small (Wright and Williams, 1989), and evidence on their existence is mixed (Benirschka and Binkley, 1995). The weight of the literature leans on convenience yields (Kaldor, 1939; Working, 1948) as the primary explanation for apparent storage at a loss (Wright and Williams, 1989). Theoretically, the marginal convenience yield decreases, approaching zero, as aggregate inventory increases. Though convenience yields are theoretically plausible, empirical support is modest (Wright and Williams, 1989), and inferences of their existence in the presence of large carryover stocks are particularly perplexing (Benirschka and Binkley, 1995).

Wright and Williams (1989) insightfully suggest that storage at a loss may be inferred from aggregated prices and inventories if one commodity is profitably stored, while a related, yet economically distinct, commodity is not stored, as the latter's expected price indicates backwardation. Significant inventories under backwardation diminish with more precise measurement, as evidenced by comparison of two supply of storage curves, respectively plotting total U.S. coffee stocks and those certified for futures contract delivery against coffee futures price spreads.[6] This result was taken as evidence that market-level findings of storage at a loss are an illusion of aggregation.

Benirschka and Binkley (1995) echo that sentiment. In their model, prices, and hence interest opportunity costs of storage, decrease with increasing transportation costs to locations further from the central market, prompting sequential delivery with remote production areas holding long-term inventories and delivering later than those nearby.[7] Citing data limitations, they offer indirect evidence that storage capacity, especially on-farm, increases with distance to the Gulf export market, and that U.S. grain prices grow faster further from this central market and at a decreasing rate as the end of the marketing year nears. Despite negligible significance in regressions on their proxy for producer price received, Benirschka and Binkley (1995) suggest the calculation of interest opportunity costs with market prices (as opposed to prices received) as the source of the disparity between interest rates and commodity price growth.[8] Brennan, Williams, and Wright's (1997) analysis of Australian wheat markets provides stronger empirical

[5] Backwardation (cantago) is the industry term for spot-futures price spreads indicating negative (positive) returns to storage (Garcia and Leuthold, 2004). While the difference between the expected future price and that for immediate delivery is less than total storage costs in markets in backwardation, the expected future price is below that for immediate delivery in an inverted market. Inversion implies backwardation, but not necessarily the converse. Backwardation has no negative price spread limit and is interpreted as a price premium for early delivery. Keynes (1930) referred to futures prices underestimating the true expected spot price as normal backwardation.

[6] This is really a joint test of the theory, data quality, and market competition. Wright and Williams (1989) find that "(S)torage of one subaggregate is consistent with backwardation of the other" (p. 8). Furthermore, the dispersion of supplies across subaggregates affects their synthetic supply of storage curves.

[7] Transportation costs decrease the price received, and hence the interest income from immediate sale.

[8] Benirschka and Binkley (1995) offer that a one-tailed test may be used to obtain a level of significance near 5% in the model for total storage capacity.

support of the spatial aggregation argument (i.e., storage at a loss was remedied with proper measure of local prices).

Frechette and Fackler (1999) caution that additive storage costs impose faster price growth at locations further from the central market if transportation bases are constant year-round, and hence, that "the relative rate of change is lower in the higher-priced demand center, even if no backwardation occurs" (p. 764). Their finding that location effects are substantially smaller than the negative effect of aggregate inventory levels on far-near corn futures spreads contradicts Benirschka and Binkley's (1995) claim that the location of inventories explains backwardations.[9]

Yoon and Brorsen (2002) found a significantly positive influence of inventory levels on far-near corn, soybean, and wheat futures spreads, which they attributed to convenience yields; as inventories decrease price growth may fall into backwardation. Peterson and Tomek (2005) explicitly modeled convenience yields, and applied to U.S. corn markets, which never face stock-outs, a rational expectations model that allows backwardation to not depend on stock-outs. Their relatively simple model, reflecting efficient markets and rational decision-makers, successfully simulated spot and futures commodity price behavior throughout much of the 1990s.

Cornell and French (1986) show that the change in nominal interest rates in response to monetary shocks during 1980-1982 was greater than that for far-near commodity price spreads. Regressing commodity futures price growth on interest rates and seasonal dummies, Fama and French (1987) find that that price growth of precious metals closely tracks nominal interest rates, while the relationship is generally insignificant for agricultural commodities, with the exception of soybeans and soybean meal.[10] The result is intuitive, as precious metals are closer substitutes for other financial assets than agricultural commodities, which generate value in processing rather than as investments.[11] Kitchen and Rausser (1989) attribute findings of significant nonstochastic commodity own-rates to convenience yields and suggest that arbitrage (transaction) costs may explain the imperfect relationship between commodity price growth and nominal interest rates.

Data and Variable Construction

Weekly corn and soybean spot prices for 23 grain elevators in seven Illinois regions (Figure 3) from October 30, 1975 through October 3, 2002 were obtained from the Illinois Ag Marketing Service. Three-month maturity Treasury bill interest rates, corresponding to the same period, were obtained from the Commodity Research Bureau, Inc. Physical commercial storage cost schedules for corn and soybeans (Table 1) in the Central Illinois Crop Reporting District (Figure 3) were compiled from personal communication with Dr. Darrel Good of the University of

---

[9] The statistical significance of the location effects varied substantially across models and its economic significance was typically much lower than that of the inventory level effects (Frechette and Fackler, 1999). Inventory level effects were consistently significant at the 5% level.
[10] Fama and French's (1987) futures price growth rates, which neglected physical storage costs and were not adjusted to an implied annual rate, were regressed on annual interest rates and seasonal dummies.
[11] Investors may also shy away from agricultural commodities due to payment responsibilities on margins.

Illinois for 1975 through 1979, from Hill, Kunda, and Rehtmeyer (1983) for 1980 through 1988, and Irwin, et. al. (2005) for 1989 through 2001.[12] Monthly storage costs, accruing after the upfront fixed costs, are prorated to the number of days in storage.

Summary statistics are presented in Table 2. Soybean price series were generally higher than corresponding corn price series and exhibited higher standard deviations. Consistent with their closer proximity to the central market (i.e., the Gulf of Mexico), southern locations (e.g., Mt. Vernon and Benton) generally exhibited higher average, maximum, and minimum corn and soybean prices than northern locations (e.g., Belvidere and Avon). The three-month Treasury bill annual interest rate averaged 6.62 percent, varying between a maximum of 16.76 percent on December 12, 1980 and a minimum of 1.56 percent on October 3, 2002, with a standard deviation of 2.89 percent.

Variables used in empirical analyses are defined in Table 3. All spot price growth rates used in empirical analyses are calculated net of physical storage costs for storage horizons motivated by Yoon and Brorsen's (2002) spreads. Price growth rates were computed over cumulative storage horizons (within any year, each horizon begins on the same harvest date with successive horizons encompassing previous horizons) and consecutive storage horizons (successive horizons begin on the date that the previous horizon ends) for comparison.[13] Cumulative storage horizons begin with the completion of harvest at the beginning of November and conclude at the end (instead of the beginning) of the closing months in Yoon and Brorsen's (2002) spreads, so that price growth may, with time, surpass the high initial fixed costs of storage (Table 1) to attain a level commensurate with interest rates (Figures 1 and 2). For instance, the price growth rate for the horizon denoted by November → January is the January 1 - November 1 logarithmic price difference, net of physical storage costs for that period. Price growth rates over consecutive storage horizons are computed analogously. Empirical analyses are also performed on pooled consecutive horizons by stacking them sequentially within years. Price growth rates are annualized (not compounded) to allow for equitable comparison with annual interest rates. The annual interest rate is the three-month Treasury bill interest rate on the day closest to the beginning of the storage horizon.

Methods and Results

Much of the preceding research on backwardation in commodity markets has relied on simple graphing (e.g., scatter-plots, etc.) and regression (e.g., least squares and maximum likelihood) techniques. Cumulative corn and soybean price growth rates net of physical storage costs, plotted over time from harvest (Figures 1 and 2, respectively), illustrate examples contrary to Benirschka and Binkley's (1995) assertion that prices grow faster at locations further from the Gulf of Mexico. Specifically, prices for corn and soybeans grow fastest at Benton in the southernmost region, Little Egypt. Price growth at Mt. Vernon, in the Wabash region, also

[12] Irwin, et. al. (2005) note that physical storage charges in central Illinois, as measured by phone surveys, have not changed from 1995 through 2003 and the cite similar rates in Hill, Kunda, and Rehtmeyer (1983).

[13] Neglecting interest charges, cumulative horizons reflect the profitability of storage from harvest onward, while consecutive horizons are consistent with an inventory-holder revisiting the storage decision under revised expectations each storage horizon or with an agent purchasing post-harvest and storing.

generally outpaces that at Sterling and at Maroa in the Northern and South Central regions, respectively. That price growth at Sterling is usually greater than that at Maroa is consistent with their assertion.

T-tests of price growth net of physical storage costs provide more insight on the validity of purported positive north-south price growth differences and the arbitrage condition that price growth should exactly cover interest opportunity costs. Statistically significant positive price growth is never found for corn (Table 4) but is for soybeans (Table 5) over some storage horizons. Statistics for the following pairwise t-test analyses are not reported for horizons with consistently statistically significant negative price growth, as nonnegative price growth eases interpretation and results are not qualitatively different.

For storage horizons when price growth is not significantly negative, pairwise t-tests of mean differences in price growth between paired elevators are reported for corn (Table 6) and soybeans (Table 7). The null hypothesis is that the mean spatial price growth difference is nonpositive (nonnegative), where the alternative is that the mean difference is positive (negative) for positive (negative) entries, indicating faster (slower) price growth in the more northern location. Consistent with Benirschka and Binkley's (1995) claim of faster relative price growth further from Gulf export markets, most of the mean differences are statistically significantly positive, especially for differences between elevators in Northern and North Central or South Central regions during traditional storage periods for corn and soybeans (Nov → April and Nov → June storage horizons). These findings also corroborate Frechette and Fackler's (1999) point that additive (physical) storage costs impose faster relative price growth further from the central market.[14] Mean differences not significantly different from zero may be interpreted as weak evidence against both claims, or alternatively, as indicating that the sites in question are two price centers in essentially the same location.

The few exceptions possessing statistically significantly negative spatial mean differences in price growth (e.g., the Sterling-Benton and Sterling-Mt. Vernon mean differences over various storage horizons for corn and soybeans) contradict Frechette and Fackler's (1999) statement. These exceptions are also inconsistent with Benirschka and Binkley's (1995) claim if price growth at the more southern location covers interest charges, especially if that of the more northern location does not.

Tables 8 and 9 contain the results of pairwise t-tests of mean differences between price growth and interest rates for corn and soybeans, respectively. Corn price growth is often statistically significantly less than the interest rate, suggesting that spot prices do not often cover the full cost of storing corn. In contrast, soybean price growth is statistically significantly less than the interest rate only for elevators in the North Central and South Central regions during the Nov → Feb storage horizon. Soybean price growth is often insignificantly different from the interest rate, and hence, generally consistent with intertemporal arbitrage conditions, but suggests larger returns in the April → June storage horizon where it exceeds the interest rate.

[14] Frechette and Fackler's (1999) model reveals that even without backwardations, which can not exist if interest rates or transportation costs equal zero, relative price growth must be lowest at the central market.

Overall, t-tests render little support in corn markets for the intertemporal arbitrage condition of equivalence between interest rates and net price growth, but more so in soybean markets. While the statistically significantly negative Sterling-Benton mean difference for both markets over the Nov → June storage horizon contradicts Benirschka and Binkley's (1995) assertion of faster relative price growth further from Gulf export markets, interpretation is hindered by the fact that prices at both elevators grow at a rate insignificantly different from the interest rate. Even clearer contradictions exist in corn markets when price growth in a more southern location is not significantly different from the interest rate, but is statistically significantly faster than at a northern location where price growth is statistically significantly less than the interest rate (e.g., the Sterling-Mt. Vernon and Sterling-Benton mean differences over Nov → July and June → July storage horizons). Such strong contradictions can not be observed in the soybean results, as price growth rates at elevators in the Northern region are never statistically significantly less than the interest rate.

Discussion and Conclusions

This research investigates explanations for the storage at a loss paradox. In particular, two implications of Benirschka and Binkley's (1995) model supporting the illusion of aggregation explanation are examined. Specifically, we test the intertemporal arbitrage condition of price growth and interest rate equivalence where stocks are held and whether prices grow faster further from the Gulf of Mexico due to lower interest opportunity costs of storage. All empirical analyses employed net of physical storage cost price growth rates. Overall, the evidence is mixed. Yet, we did not find that price growth necessarily increases with distance from the Gulf of Mexico. Nor did we find that price growth must exactly encompass interest rates. Both of these findings undermine the foundation of Benirschka and Binkley's (1995) model, and hence, their argument for concluding that all empirical observations of storage at a loss can be remedied by disaggregating the data.

Pairwise t-tests were performed to evaluate whether spot price growth is faster in northern Illinois, due to lower interest opportunity costs of storage, than in southern Illinois where prices are higher. Price growth is often statistically significantly faster in more northern locations for corn (Table 6) and soybeans (Table 7), but Frechette and Fackler (1999) caution that additive (physical) storage costs alone impose faster relative price growth further from the central market. The finding that corn price growth is generally statistically significantly less than the interest rate (Table 8) supports Frechette and Fackler's (1999) point. In contrast, soybean price growth is often insignificantly different from the interest rate, and hence, generally consistent with intertemporal arbitrage conditions (Table 9). Observations of statistically significantly slower price growth in the north contradict Frechette and Fackler (1999) and appear to be inconsistent with Benirschka and Binkley's (1995) claim of faster relative price growth in the north stemming from a comparative advantage in interest opportunity costs.

Clear contradictions exist in corn markets when price growth in a more southern location is not significantly different from the interest rate, but is statistically significantly faster than at a northern location where price growth is statistically significantly less than the interest rate (e.g., the Sterling-Mt. Vernon and Sterling-Benton differences over Nov → July and June → July storage horizons). Weaker contradictions can be observed in the soybean results (e.g., the statistically significantly negative Sterling-Benton mean difference for the Nov → June storage horizon), as price growth rates at elevators in the Northern region are never statistically significantly less than the interest rate.

Overall, t-tests render little support in corn markets for intertemporal arbitrage conditions, but more so in soybean markets. This discrepancy is consistent with Fama and French's (1987) finding that price growth for soybeans, but not corn, generally tracks interest rates. Contrary to Benirschka and Binkley (1995), results support the hypothesis that other factors, in addition to interest rates, may be driving price growth, particularly for corn. Why would soybean prices grow at the rate of interest while corn prices grow at a significantly slower rate?

Corn results are consistent with Peterson and Tomek's (2005) strong evidence for convenience yields in that market. Initially, one may suspect that the convenience yield has disappeared in soybean markets with increasing year-round availability from Brazilian production, while it persists in corn which is produced on a smaller scale in South America. However, differences between net price growth and interest rates for both corn and soybeans over the Nov → June storage horizon (figures 4 and 5, respectively) oscillate around their respective means (reported in tables 8 and 9, respectively) in a fairly consistent pattern. Had a convenience yield previously existed in soybean markets, the difference between soybean price growth and interest rates would have been less than its mean in early years and greater more recently. The difference between corn price growth and interest rates appears to have become more negative since 1996, which would be consistent with increased convenience yields from ethanol production. Additional observations beyond 2001 would help to substantiate or negate that possibility. Note that three-month Treasury bill interest rates imply conservative interest charges. Had higher interest rates been considered, the pattern of the differences between soybean price growth and interest rates would shift downward, possibly implying a convenience yield, albeit smaller than that of corn.

As an alternative to convenience yields, Chavas, Despins, and Fortenbery (2000) offer that Brazil's increasing soybean production decreased storage incentives, and thus, sales and transaction costs incurred in the spring and summer in the U.S.[15] Yet, this explanation is also inconsistent with the information conveyed in Figures 4 and 5 for the same reasons as the proposition that increased Brazilian soybean production shrank convenience yields. Another potential explanation is the prevalence of government programs for corn relative to soybeans for the sample period. Spot prices may be less relevant to storage decisions in the presence of additional government assistance. Clearly, further investigation of the observed differences in corn and soybean price behavior is warranted. Future research may extend the sample period considered in this study, compare results across different levels of aggregation (e.g., regional- vs. elevator-level prices), and/or employ regression analyses to explore more deeply the impacts of interest rates and inventories on commodity price growth.

[15] Convenience yields typically are realized by agents that use the inventory as an input, whereas transaction costs are relevant to all would-be participants in inventory management. In contrast to convenience yields, which are generally thought to depend on inventory levels, Chavas, Despins, and Fortenbery (2000) find that marginal transaction costs depend on expected changes in inventory.

References

Benirschka, Martin and James K. Binkley. (August, 1995). "Optimal Storage and Marketing Over Space and Time." *American Journal of Agricultural Economics Association*. 77: 512-524.

Brennan, D., J.C. Williams, and B.D. Wright. (1997). "Convenience Yield without the Convenience: A Spatial-Temporal Interpretation of Storage under Backwardation." *Economic Journal*. 107: 1009-1022.

Chavas, Jean-Paul, Paula M. Despins, and T. Randy Fortenbery. (May, 2000). "Inventory Dynamics Under Transaction Costs." *American Journal of Agricultural Economics*. 82: 260-273.

Commodity Research Bureau, Inc. Info Tech CD. Copyright 2003.

Cornell, Bradford, and Kenneth R. French. (1986). "Commodity Own Rates, Real Interest Rates, and Money Supply Announcements." *Journal of Monetary Economics*. 18(1986): 3-20.

Fama, E.F., and K.R. French. (1987). "Commodity Futures Prices: Some Evidence on Forecast Power, Premiums, and the Theory of Storage." *The Journal of Business*. 60(1): 55-73.

Frechette, Darren L. and Paul L. Fackler. (November, 1999). "What Causes Commodity Price Backwardation?" *American Journal of Agricultural Economics*. 81: 761-771.

Garcia, Phillip and Raymond Leuthold. (2004). "A Selected Review of Agricultural Commodity futures and Options Markets." *European Review of Agricultural Economics*. 31(3): 235-272.

Garcia, P. and D. Good. (1983). "Analysis of Factors Influencing Illinois Regional Corn Basis, 1971-81." Proceedings of the Applied Commodity Price Forecasting and Risk Management Conference. NCR-134. pp. 306-326.

Good, Darrel. Personal communication regarding 1973 to 1979 storage costs schedules.

Hill, L., E. Kunda, and C. Rehtmeyer. (1983). "Price Related Characteristics of Illinois Grain Elevators, 1982," AE-4561, Department of Agricultural Economics, University of Illinois at Urbana-Champaign. (September).

Irwin, S.H., D.L. Good, J. Martines-Filho, L.A. Hagedorn. (2005). "The Pricing Performance of Market Advisory Services in Corn and Soybeans Over 1995-2003." *AgMas Project Research Report 2005-01*. (March). Downloaded from the University of Illinois *farmdoc* webpage http://www.farmdoc.uiuc.edu/agmas/reports/index.html on May 1, 2005.

Kaldor, N. (October, 1939). "Speculation and Economic Stability." *Review of Economic Studies*. 7: 1-27.

Keynes, J.M. (1930). *A Treatise on Money*. Volume 2. New York: Harcourt.

Kitchen, J., and Gordon Rausser. (1989). "Interest Rates and Commodity Prices." *The Journal of Agricultural Economics Research*. 41(2): 5-11.

Peterson, Hikaru H. and William G. Tomek. (2005). "How Much of Commodity Price Behavior Can a Rational Expectations Storage Model Explain?" *Agricultural Economics*. Forthcoming.

USDA Agricultural Marketing Service. "Illinois Grain Reports." http://www.ams.usda.gov/lsmnpubs/GIL.htm

Working, H. (1948). "Theory of the Inverse Carrying Charge in Futures Markets." *Journal of Farm Economics*. 30: 1-28.
Working, H. (1949). "The Investigation of Economic Expectations." American *Economic Review*. 39: 150-166.
Wright, Brian D. and Jeffrey C. Williams. (February, 1989). "A Theory of Negative Prices for Storage." *The Journal of Futures Markets*. 9(1): 1-13.
Yoon, Byung-Sam and B. Wade Brorsen. (2002). "Market Inversion in Commodity Futures Prices." *Journal of Agricultural and Applied Economics*. 34(3): 459-476.

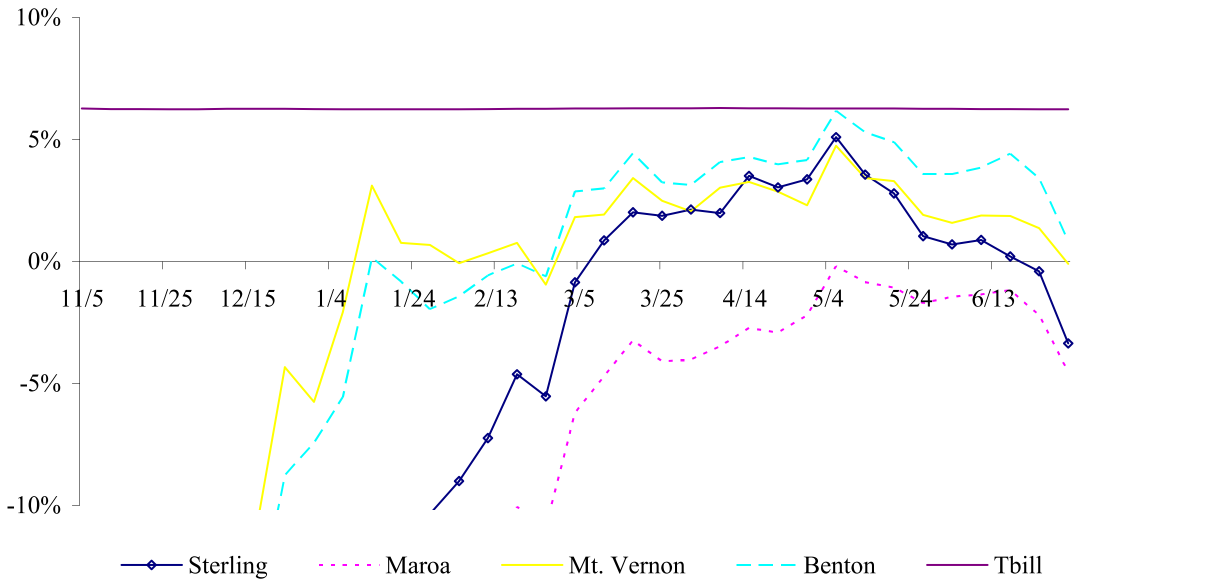

Figure 1. Annual Average Interest Rates and Net Corn Price Growth from Harvest, 1975 – 2001.

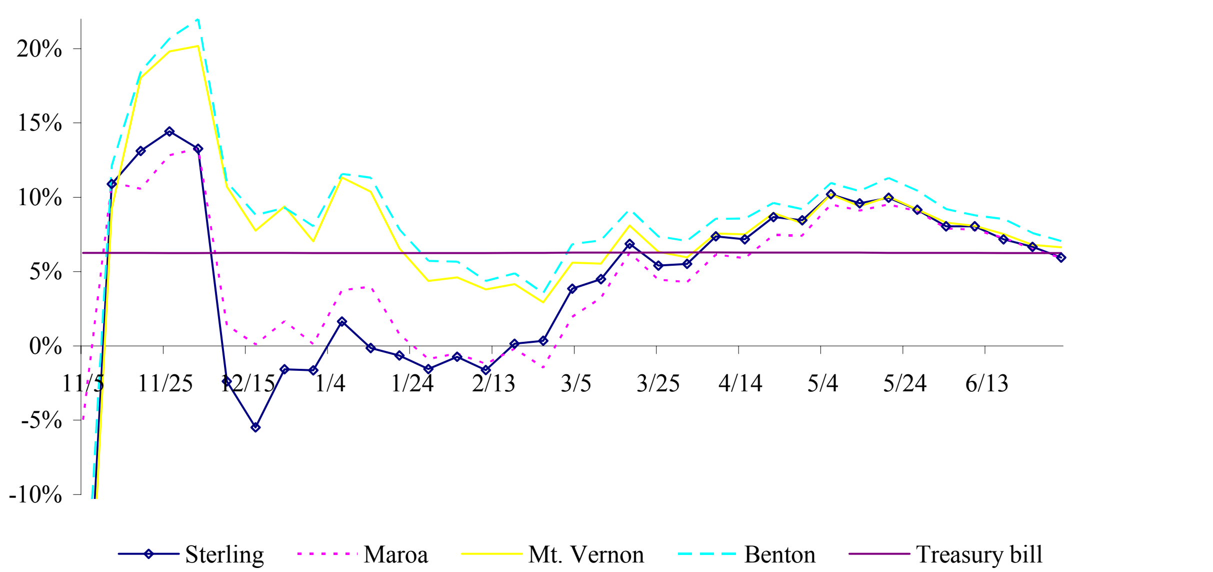

Figure 2. Annual Average Interest Rates and Net Soybean Price Growth from Harvest, 1975 – 2001.

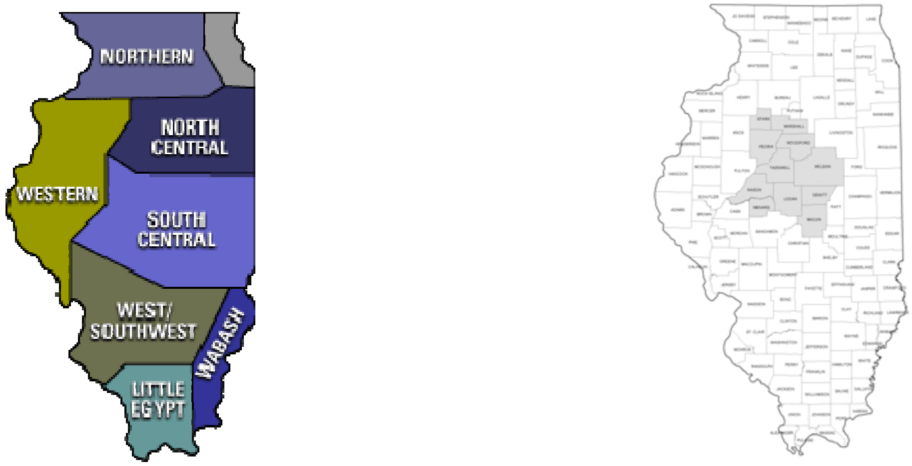

Figure 3. Illinois Price Reporting Districts and Central Illinois Crop Reporting District.

Figure 4. Difference between Net Corn Price Growth and Interest Rates for the November → June Storage Horizon, 1975 – 2001.

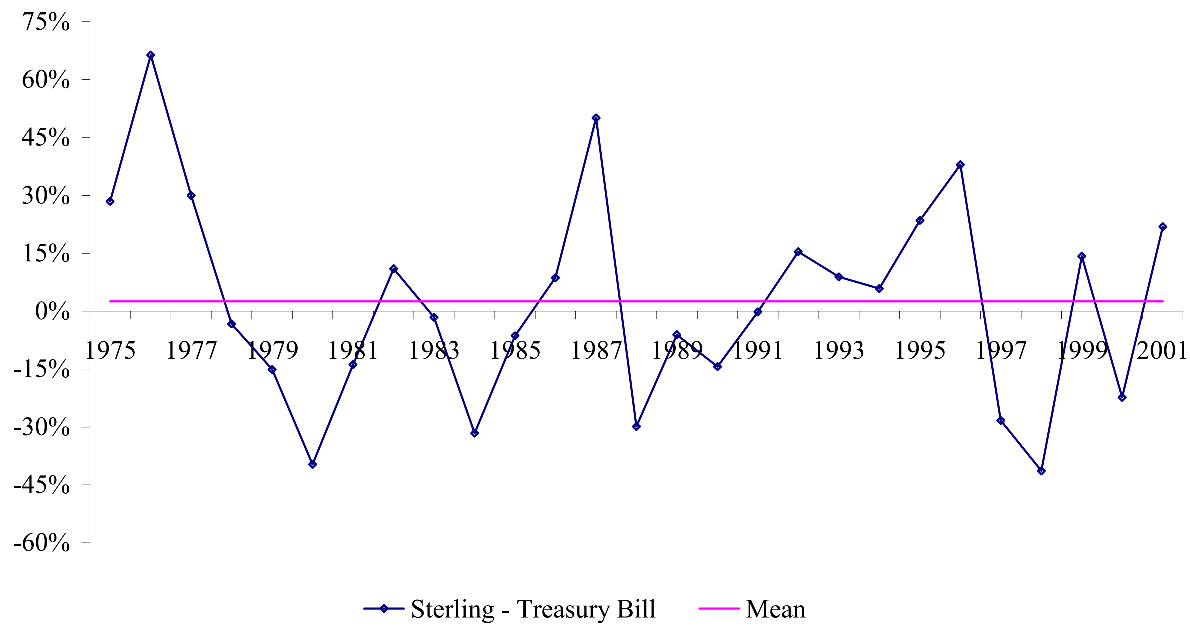

Figure 5. Difference between Net Soybean Price Growth and Interest Rates for the November → June Storage Horizon, 1975 – 2001.

Table 1. Commercial Physical Storage Cost Schedules.

	Corn ($/bu)				Soybeans ($/bu)	
Period	Warehousing		Drying	Shrinkage	Warehousing	
	Harvest → Jan 31	Monthly (after Jan 31)			Harvest → Jan 31	Monthly (after Jan 31)
1975 - 1979†	0.100	0.015	0.010	1.30%	0.100	0.015
	Harvest → Jan 31	Monthly (after Jan 31)			Harvest → Jan 31	Monthly (after Jan 31)
1980 - 1988‡	0.129	0.021	0.023	1.30%	0.142	0.024
	Harvest → Dec 31	Monthly (after Dec 31)			Harvest → Dec 31	Monthly (after Dec 31)
1989 - 2001F	0.130	0.020	0.020	1.30%	0.130	0.020

† Personal communication with Dr. Darrel Good, University of Illinois at Urbana-Champaign.
‡ Hill, L., E. Kunda, and C. Rehtmeyer. (1983). "Price Related Characteristics of Illinois Grain Elevators, 1982," AE-4561, Department of Agricultural Economics, University of Illinois at Urbana-Champaign.
F Irwin, S.H., D.L. Good, J. Martines-Filho, L.A. Hagedorn. (2005). "The Pricing Performance of Market Advisory Services in Corn and Soybeans Over 1995-2003." *AgMas Project Research Report 2005-01*.

Table 2. Summary Statistics for Prices and Annual Interest Rates.

	Corn				Soybean			
Price ($/bu.)	Mean	SD	Max	Min	Mean	SD	Max	Min
Northern Region								
Belvidere	2.35	0.54	5.28	1.18	5.95	1.12	10.20	3.79
Sterling	2.38	0.53	5.16	1.14	5.99	1.11	10.22	3.85
Erie	2.38	0.53	5.16	1.14	5.99	1.11	10.22	3.85
Western Region								
Avon	2.36	0.54	5.12	1.06	5.97	1.12	9.94	3.81
Galesburg	2.37	0.53	5.12	1.11	5.99	1.11	10.17	3.85
Stronghurst	2.38	0.53	5.15	1.12	6.01	1.11	10.20	3.86
North Central Region								
Cooksville	2.41	0.54	5.16	1.19	6.06	1.12	10.23	3.83
Manteno	2.41	0.54	5.31	1.26	6.03	1.11	10.21	3.84
Gridley	2.42	0.54	5.17	1.17	6.04	1.12	10.20	3.81
Ashkum	2.43	0.54	5.19	1.27	6.05	1.11	10.20	3.91
South Central Region								
Mason City	2.42	0.54	5.19	1.12	6.04	1.12	10.23	3.88
Jamaica	2.42	0.55	5.26	1.28	6.08	1.11	10.08	3.90
Elkhart	2.43	0.54	5.20	1.22	6.07	1.12	10.20	3.88
Stonington	2.43	0.54	5.23	1.23	6.10	1.13	10.19	3.93
Chestnut	2.44	0.54	5.19	1.24	6.08	1.12	10.15	3.91
Maroa	2.44	0.54	5.21	1.24	6.09	1.12	10.19	3.92
Ludlow	2.45	0.54	5.33	1.21	6.11	1.11	10.10	3.93
Farmer City	2.46	0.54	5.19	1.24	6.09	1.12	10.17	3.89
West Southwest Region								
Carlinville	2.40	0.55	5.16	1.16	6.04	1.12	10.18	3.98
Altamont	2.41	0.54	5.20	1.24	6.04	1.11	10.10	3.95
Nashville	2.44	0.56	5.37	1.24	6.05	1.12	10.18	3.94
Wabash Region								
Mt. Vernon	2.49	0.55	5.20	1.21	6.16	1.13	10.31	4.03
Little Egypt Region								
Benton	2.50	0.54	5.22	1.26	6.06	1.10	10.17	3.98

	Mean	SD	Max	Min
Three-Month T-Bill (%)	6.62	2.89	16.76	1.56

Note: Weekly prices and three-month Treasury bill annual interest rates span from 10/30/1975 through 10/3/2002 and from 10/31/1975 through 10/3/2002, respectively.

Table 3. Definitions of Variables.

Variable	Description
<u>Net price growth rate</u>: $\%\Delta p_{i,t} = \frac{\left[\ln\left(p_i^{\tau} - s_t\right) - \ln p_i^t\right]}{d/365}$	The annualized logarithmic price difference at market *i* between the net price $(p_i^{\tau} - s_t)$ on the Thursday nearest to the beginning of the month concluding the storage period and the price p_i^t on the Thursday nearest to the beginning of the month initiating the storage period. Physical storage costs s_t accrue over the storage period, which begins and ends on Thursdays *t* and *τ*, respectively. Annualizing entails dividing the logarithmic price difference by the fraction of storage period days $d = \tau - t$ in a year.
<u>Annual interest rate</u>:	Three-month Treasury bill annual interest rate reported on the day closest to the beginning of the storage period *t*.

Table 4. T-Tests of Corn Price Growth Net of Physical Storage Costs, 1975 – 2001.

	Cumulative Storage Horizons					Consecutive Storage Horizons				
Location	Nov → Jan	Nov → April	Nov→ June	Nov → July	Nov → Oct	Jan → April	April → June	June → July	July → Oct	Pooled
Northern										
Sterling	-0.2184***	0.0213	0.0104	-0.0335	-0.2087***	-0.0056	-0.0144	-0.2568	-0.5781***	-0.2185***
Erie	-0.2304***	0.0112	0.0072	-0.0355	-0.2105***	-0.0146	-0.0004	-0.2520	-0.5794***	-0.2192***
Belvidere	-0.2495***	-0.0156	0.0000	-0.0361	-0.1855***	-0.0482	0.0412	-0.2179	-0.5003***	-0.2017***
Western										
Galesburg	-0.2275***	-0.0176	-0.0149	-0.0487	-0.2074***	-0.0632	-0.0053	-0.2158	-0.5388***	-0.2138***
Stronghurst	-0.2352***	0.0066	0.0067	-0.0323	-0.2031***	-0.0183	0.0087	-0.2303	-0.5651***	-0.2129***
Avon	-0.2261***	-0.0132	-0.0125	-0.0527	-0.2144***	-0.0570	-0.0079	-0.2535	-0.5507***	-0.2240***
North Central										
Manteno	-0.2364***	-0.0179	-0.0025	-0.0378	-0.1939***	-0.0548	0.0380	-0.2140	-0.5235***	-0.2032***
Ashkum	-0.2248***	-0.0224	-0.0135	-0.0379	-0.2086***	-0.0681	0.0120	-0.1574	-0.5695***	-0.2070***
Gridley	-0.2464***	-0.0352	-0.0214	-0.0491	-0.2028***	-0.0748	0.0164	-0.1826	-0.5257***	-0.2065***
Cooksville	-0.2601***	-0.0385	-0.0322	-0.0513	-0.2099***	-0.0726	-0.0112	-0.1392	-0.5428***	-0.2099***
South Central										
Farmer City	-0.2417***	-0.0278	-0.0215	-0.0464	-0.1982***	-0.0633	-0.0014	-0.1673	-0.5190***	-0.2035***
Chestnut	-0.2617***	-0.0381	-0.0237	-0.0489	-0.2034***	-0.0687	0.0169	-0.1711	-0.5287***	-0.2077***
Maroa	-0.2756***	-0.0402	-0.0171	-0.0454	-0.1985***	-0.0631	0.0444	-0.1847	-0.5218***	-0.2050***
Stonington	-0.2579***	-0.0362	-0.0191	-0.0442	-0.2038***	-0.0687	0.0274	-0.1663	-0.5411***	-0.2064***
Ludlow	-0.2175***	-0.0206	-0.0158	-0.0370	-0.1988***	-0.0682	0.0002	-0.1389	-0.5420***	-0.1971***
Jamaica	-0.1798**	0.0017	0.0057	-0.0189	-0.1991***	-0.0596	0.0177	-0.1415	-0.5842***	-0.1944***
Mason City	-0.2106***	-0.0128	-0.0122	-0.0470	-0.1943***	-0.0617	-0.0077	-0.2197	-0.5034***	-0.2036***
Elkhart	-0.2510***	-0.0368	-0.0228	-0.0485	-0.2113***	-0.0744	0.0166	-0.1728	-0.5549***	-0.2124***
Wabash										
Mt. Vernon	-0.0575	0.0206	0.0192	-0.0009	-0.2027***	-0.1018	0.0159	-0.1024	-0.6372***	-0.1812***
West Southwest										
Altamont	-0.1205	0.0224	0.0180	-0.0098	-0.2055***	-0.0654	0.0075	-0.1502	-0.6226***	-0.1948***
Carlinville	-0.1521*	-0.0053	0.0000	-0.0251	-0.2063***	-0.0896	0.0149	-0.1493	-0.5896***	-0.1984***
Nashville	-0.0900	0.0318	0.0283	0.0050	-0.2046***	-0.0684	0.0193	-0.1159	-0.6531***	-0.1852***
Little Egypt										
Benton	-0.0744	0.0315	0.0359	0.0083	-0.2024***	-0.0736	0.0456	-0.1357	-0.6572***	-0.1855***

Note: Annual observations = 27. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. For positive entries, H_0: *Price growth* ≤ *0* and H_a: *Price growth* > *0*. For negative entries, H_0: *Price growth* ≥ *0* and H_a: *Price growth* < *0*.

Table 5. T-Tests of Soybean Price Growth Net of Physical Storage Costs, 1975 – 2001.

	Cumulative Storage Horizons					Consecutive Storage Horizons				
Location	Nov → Dec	Nov → Feb	Nov → April	Nov → June	Nov → July	Dec → Feb	Feb → April	April → June	June → July	Pooled
Northern										
Sterling	0.1444	-0.0156	0.0553	0.0916**	0.0626	-0.2127***	0.1064	0.1863**	-0.1256	0.0220
Erie	0.1588*	-0.0113	0.0564	0.0950**	0.0646	-0.2129***	0.1031	0.1958**	-0.1322	0.0247
Belvidere	0.1270	0.0008	0.0476	0.0891**	0.0599	-0.1836***	0.0645	0.1975**	-0.1284	0.0175
Western										
Galesburg	0.1045	-0.0217	0.0366	0.0810*	0.0550	-0.2049***	0.0703	0.1975**	-0.1113	0.0123
Stronghurst	0.1712*	-0.0084	0.0552	0.0931**	0.0683*	-0.2138***	0.0962	0.1920**	-0.0962	0.0318
Avon	0.0949	-0.0260	0.0375	0.0789*	0.0524	-0.2071***	0.0784	0.1873**	-0.1157	0.0107
North Central										
Manteno	0.0638	-0.0301	0.0351	0.0814*	0.0495	-0.1990***	0.0788	0.2028***	-0.1481	0.0011
Ashkum	0.0662	-0.0204	0.0359	0.0806*	0.0591	-0.1854**	0.0669	0.1981***	-0.0762	0.0160
Gridley	0.0362	-0.0398	0.0266	0.0730*	0.0471	-0.2008***	0.0719	0.1952***	-0.1135	0.0000
Cooksville	0.0268	-0.0421	0.0271	0.0701*	0.0449	-0.1994***	0.0769	0.1835**	-0.1130	-0.0029
South Central										
Farmer City	0.0476	-0.0272	0.0286	0.0768*	0.0503	-0.1864**	0.0595	0.2036***	-0.1115	0.0049
Chestnut	0.0625	-0.0291	0.0309	0.0782*	0.0522	-0.1960***	0.0676	0.2025***	-0.1058	0.0083
Maroa	0.1283	-0.0089	0.0428	0.0906**	0.0608	-0.1938***	0.0676	0.2158***	-0.1195	0.0209
Stonington	0.0571	-0.0279	0.0305	0.0797*	0.0544	-0.1914***	0.0652	0.2091***	-0.0989	0.0099
Ludlow	0.0581	-0.0266	0.0325	0.0748*	0.0538	-0.1894***	0.0680	0.1863**	-0.0787	0.0107
Jamaica	0.0352	-0.0357	0.0328	0.0755*	0.0502	-0.1937***	0.0814	0.1880**	-0.1102	0.0019
Mason City	0.1350	-0.0017	0.0356	0.0837*	0.0575	-0.1880***	0.0403	0.2100***	-0.1129	0.0186
Elkhart	0.0708	-0.0217	0.0320	0.0816*	0.0556	-0.1892***	0.0597	0.2120***	-0.1027	0.0122
Wabash										
Mt. Vernon	0.1981*	0.0437	0.0596	0.0918**	0.0695*	-0.1486**	0.0344	0.1755**	-0.0792	0.0385
West Southwest										
Altamont	0.1588*	0.0101	0.0497	0.0930**	0.0648	-0.1819**	0.0567	0.2065***	-0.1149	0.0276
Carlinville	0.1121	-0.0039	0.0322	0.0816*	0.0572	-0.1823***	0.0349	0.2115***	-0.0917	0.0179
Nashville	0.1996*	0.0313	0.0523	0.0952**	0.0688	-0.1692**	0.0335	0.2072***	-0.0894	0.0390
Little Egypt										
Benton	0.2068**	0.0573	0.0707	0.1044**	0.0737*	-0.1351**	0.0407	0.1919**	-0.1222	0.0368

Note: Annual observations = 27. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. For positive entries, H_0: *Price growth* ≤ *0* and H_a: *Price growth > 0*. For negative entries, H_0: *Price growth* ≥ *0* and H_a: *Price growth < 0*.

Table 6. Pairwise T-Tests of Spatial Difference in Net Corn Price Growth, 1975 – 2001.

	Cumulative Storage Horizons			Consecutive Storage Horizons		
	Nov → April	Nov → June	Nov → July	Jan → April	April → June	June → July
Northern						
Belvidere - Sterling	-0.0370**	-0.0104	-0.0026	-0.0426**	0.0557**	0.0389
Erie - Sterling	-0.0102*	-0.0032	-0.0020	-0.0089	0.0140	0.0048
Western						
Sterling - Galesburg	0.0390***	0.0254***	0.0152*	0.0576***	-0.0092	-0.0410
Sterling - Stronghurst	0.0148	0.0037	-0.0012	0.0127	-0.0231	-0.0265
Sterling - Avon	0.0345***	0.0229**	0.0192**	0.0514**	-0.0065	-0.0033
North Central						
Sterling - Manteno	0.0393***	0.0130	0.0042	0.0492***	-0.0524*	-0.0427
Sterling - Ashkum	0.0437***	0.0240**	0.0044	0.0624***	-0.0264	-0.0994**
Sterling - Gridley	0.0565***	0.0318***	0.0155	0.0692***	-0.0308	-0.0742*
Sterling - Cooksville	0.0599***	0.0426***	0.0178*	0.0669***	-0.0032	-0.1176***
South Central						
Sterling - Farmer City	0.0492***	0.0319**	0.0128	0.0577**	-0.0131	-0.0895**
Sterling - Chestnut	0.0595***	0.0341**	0.0154	0.0630***	-0.0313	-0.0856**
Sterling - Maroa	0.0616***	0.0275**	0.0119	0.0575***	-0.0588*	-0.0721*
Sterling - Stonington	0.0575***	0.0296**	0.0107	0.0630***	-0.0419	-0.0905**
Sterling - Ludlow	0.0420***	0.0263**	0.0035	0.0626***	-0.0146	-0.1179***
Sterling - Jamaica	0.0196	0.0047	-0.0146	0.0540***	-0.0321	-0.1153**
Sterling - Mason City	0.0342***	0.0226**	0.0135**	0.0560***	-0.0067	-0.0371*
Sterling - Elkhart	0.0581***	0.0332***	0.0149	0.0688***	-0.0311	-0.0840**
Wabash						
Sterling - Mt. Vernon	0.0008	-0.0088	-0.0326***	0.0962***	-0.0303	-0.1544***
West Southwest						
Sterling - Altamont	-0.0010	-0.0076	-0.0237*	0.0598**	-0.0219	-0.1066**
Sterling - Carlinville	0.0267**	0.0104	-0.0084	0.0839***	-0.0294	-0.1075***
Sterling - Nashville	-0.0105	-0.0179	-0.0385***	0.0628***	-0.0337	-0.1409***
Little Egypt						
Sterling - Benton	-0.0101	-0.0254**	-0.0418***	0.0680***	-0.0600**	-0.1211***

Annual observations = 27. ***, **, * denote statistical significance at the 1%, 5%, 10% level, respectively. For positive entries, indicating faster price growth in the more northern location, H_0: *The mean difference* ≤ *0* and H_a: *The mean difference > 0*. For negative entries, indicating faster price growth in the more southern location, H_0: *The mean difference* ≥ *0* and H_a: *The mean difference < 0*.

Table 7. Pairwise T-Tests of Spatial Difference in Net Soybean Price Growth, 1975 – 2001.

	Cumulative Storage Horizons					Consecutive Storage Horizons			
	Nov → Dec	Nov → Feb	Nov → April	Nov → June	Nov → July	Feb → April	April → June	June → July	Pooled
Northern									
Belvidere - Sterling	-0.0174	0.0164*	-0.0077	-0.0025	-0.0027	-0.0419***	0.0113	-0.0028	-0.0045
Erie - Sterling	0.0144	0.0043	0.0011	0.0035*	0.0020	-0.0033	0.0096*	-0.0066	0.0027
Western									
Sterling - Galesburg	0.0399	0.0061	0.0187***	0.0106**	0.0076*	0.0361***	-0.0113	-0.0143	0.0097
Sterling - Stronghurst	-0.0268	-0.0072	0.0001	-0.0015	-0.0057	0.0102	-0.0058	-0.0294	-0.0098*
Sterling - Avon	0.0495	0.0104	0.0177***	0.0127**	0.0102**	0.0280**	-0.0010	-0.0100	0.0113
North Central									
Sterling - Manteno	0.0806**	0.0145	0.0201**	0.0102*	0.0131**	0.0276**	-0.0165	0.0224	0.0209**
Sterling - Ashkum	0.0782**	0.0049	0.0193**	0.0109*	0.0035	0.0395***	-0.0118	-0.0495**	0.0060
Sterling - Gridley	0.1082***	0.0242**	0.0287***	0.0186***	0.0155***	0.0345***	-0.0089	-0.0121	0.0220**
Sterling - Cooksville	0.1176***	0.0265**	0.0282***	0.0214***	0.0177***	0.0296***	0.0028	-0.0127	0.0249***
South Central									
Sterling - Farmer City	0.0968**	0.0116	0.0266***	0.0147**	0.0123**	0.0470***	-0.0173	-0.0141	0.0171*
Sterling - Chestnut	0.0819**	0.0135	0.0244***	0.0134**	0.0104*	0.0388***	-0.0163	-0.0199	0.0137
Sterling - Maroa	0.0161	-0.0067	0.0124	0.0010	0.0018	0.0388***	-0.0295**	-0.0061	0.0010
Sterling - Stonington	0.0873**	0.0123	0.0247***	0.0118*	0.0082*	0.0412***	-0.0228*	-0.0267	0.0121
Sterling - Ludlow	0.0863**	0.0110	0.0227***	0.0167**	0.0088*	0.0384***	0.0000	-0.0469	0.0113
Sterling - Jamaica	0.1092**	0.0201	0.0225**	0.0160**	0.0124*	0.0251**	-0.0018	-0.0154	0.0201**
Sterling - Mason City	0.0094	-0.0139	0.0196***	0.0078*	0.0051	0.0662***	-0.0237**	-0.0127	0.0034
Sterling - Elkhart	0.0735**	0.0061	0.0233***	0.0100*	0.0070	0.0467***	-0.0257*	-0.0229	0.0098
Wabash									
Sterling - Mt. Vernon	-0.0537*	-0.0593***	-0.0044	-0.0002	-0.0069*	0.0721***	0.0108	-0.0464**	-0.0165**
West Southwest									
Sterling - Altamont	-0.0144	-0.0257*	0.0056	-0.0015	-0.0022	0.0497***	-0.0202	-0.0107	-0.0056
Sterling - Carlinville	0.0323	-0.0117	0.0231***	0.0099**	0.0054	0.0715***	-0.0253**	-0.0339**	0.0041
Sterling - Nashville	-0.0552*	-0.0469***	0.0030	-0.0037	-0.0062	0.0729***	-0.0210	-0.0363*	-0.0170*
Little Egypt									
Sterling - Benton	-0.0624**	-0.0729***	-0.0154**	-0.0129**	-0.0111**	0.0657***	-0.0057	-0.0034	-0.0148*

Annual observations = 27. ***, **, * denote statistical significance at the 1%, 5%, 10% level, respectively. For positive entries, indicating faster price growth in the more northern location, H_0: *The mean difference* ≤ 0 and H_a: *The mean difference* > 0. For negative entries, indicating faster price growth in the more southern location, H_0: *The mean difference* ≥ 0 and H_a: *The mean difference* < 0.

Table 8. Pairwise T-Tests between Net Corn Price Growth and Interest Rates, 1975 – 2001.

	Cumulative Storage Horizons			Consecutive Storage Horizons		
	Nov → April	Nov → June	Nov → July	Jan → April	April→ June	June → July
Northern						
Belvidere	-0.0820*	-0.0663*	-0.1025**	-0.1139*	-0.0262	-0.2831
Erie	-0.0552	-0.0591	-0.1019**	-0.0803	-0.0678	-0.3172*
Sterling	-0.0450	-0.0559	-0.0999**	-0.0714	-0.0818	-0.3220*
Western						
Galesburg	-0.0840*	-0.0813**	-0.1151**	-0.1290*	-0.0727	-0.2810
Stronghurst	-0.0598	-0.0596	-0.0986**	-0.0841	-0.0587	-0.29552
Avon	-0.0795*	-0.0788*	-0.1191**	-0.1228*	-0.0753	-0.31869*
North Central						
Manteno	-0.0843*	-0.0689*	-0.1041**	-0.1205*	-0.0295	-0.2793
Ashkum	-0.0887*	-0.0799*	-0.1042**	-0.1338**	-0.0554	-0.2226
Gridley	-0.1015**	-0.0877**	-0.1154**	-0.1406**	-0.0510	-0.2478
Cooksville	-0.1049**	-0.0985**	-0.1176**	-0.1383**	-0.0786	-0.2045
South Central						
Farmer City	-0.0942**	-0.0878**	-0.1127**	-0.1290*	-0.0688	-0.2325
Chestnut	-0.1045**	-0.0900**	-0.1153**	-0.1344**	-0.0505	-0.2364
Maroa	-0.1066**	-0.0834*	-0.1118**	-0.1288*	-0.0230	-0.2499
Stonington	-0.1025**	-0.0855*	-0.1106**	-0.1344**	-0.0400	-0.2316
Ludlow	-0.0870*	-0.0822*	-0.1034*	-0.1339**	-0.0672	-0.2042
Jamaica	-0.0646	-0.0606	-0.0853*	-0.1254*	-0.0497	-0.2068
Mason City	-0.0792*	-0.0785*	-0.1134**	-0.1274*	-0.0751	-0.2850
Elkhart	-0.1031**	-0.0891**	-0.1148**	-0.1401**	-0.0508	-0.2380
Wabash						
Mt. Vernon	-0.0458	-0.0471	-0.0672	-0.1676**	-0.0515	-0.1677
West Southwest						
Altamont	-0.0439	-0.0483	-0.0762	-0.1311**	-0.0599	-0.2154
Carlinville	-0.0717*	-0.0663*	-0.0915*	-0.1553**	-0.0525	-0.2145
Nashville	-0.0345	-0.0380	-0.0614	-0.1341**	-0.0481	-0.1812
Little Egypt						
Benton	-0.0349	-0.0305	-0.0580	-0.1394**	-0.0218	-0.2009

Annual observations = 27. ***, **, * denote statistical significance at the 1%, 5%, 10% level, respectively. For positive entries, H_0: *The mean difference* ≤ *0* and H_a: *The mean difference > 0*. For negative entries, H_0: *The mean difference* ≥ *0* and H_a: *The mean difference < 0.*

Table 9. Pairwise T-Tests between Net Soybean Price Growth and Interest Rates, 1975 – 2001.

	Cumulative Storage Horizons					Consecutive Storage Horizons			
	Nov → Dec	Nov → Feb	Nov → April	Nov → June	Nov → July	Feb → April	April → June	June → July	Pooled
Northern									
Belvidere	0.0607	-0.0656	-0.0188	0.0227	-0.0064	-0.0018	0.1301*	-0.1936	-0.0472
Erie	0.0924	-0.0777	-0.0100	0.0287	-0.0017	0.0368	0.1284*	-0.1974	-0.0400
Sterling	0.0780	-0.0819	-0.0111	0.0252	-0.0037	0.0401	0.1189*	-0.1909	-0.0427
Western									
Galesburg	0.0381	-0.0880	-0.0298	0.0146	-0.0113	0.0040	0.1301*	-0.1765	-0.0524
Stronghurst	0.1049	-0.0748	-0.0112	0.0267	0.0020	0.0300	0.1246*	-0.1615	-0.0329
Avon	0.0286	-0.0923	-0.0288	0.0126	-0.0140	0.0121	0.1199*	-0.1809	-0.0540
North Central									
Manteno	-0.0026	-0.0965*	-0.0312	0.0150	-0.0169	0.0126	0.1354*	-0.2133	-0.0636
Ashkum	-0.0001	-0.0868*	-0.0304	0.0143	-0.0073	0.0007	0.1307*	-0.1414	-0.0487
Gridley	-0.0302	-0.1061*	-0.0398	0.0066	-0.0192	0.0057	0.1278*	-0.1787	-0.0647
Cooksville	-0.0395	-0.1085*	-0.0392	0.0038	-0.0214	0.0106	0.1161*	-0.1782	-0.0676
South Central									
Farmer City	-0.0188	-0.0935*	-0.0377	0.0105	-0.0161	-0.0068	0.1362**	-0.1767	-0.0598
Chestnut	-0.0038	-0.0954*	-0.0354	0.0119	-0.0141	0.0014	0.1351*	-0.1710	-0.0564
Maroa	0.0620	-0.0752*	-0.0235	0.0242	-0.0055	0.0013	0.1484**	-0.1847	-0.0438
Stonington	-0.0092	-0.0942*	-0.0358	0.0134	-0.0119	-0.0011	0.1417**	-0.1641	-0.0548
Ludlow	-0.0082	-0.0929*	-0.0338	0.0085	-0.0126	0.0017	0.1189*	-0.1439	-0.0540
Jamaica	-0.0312	-0.1020*	-0.0336	0.0092	-0.0161	0.0151	0.1206*	-0.1754	-0.0628
Mason City	0.0687	-0.0681	-0.0307	0.0174	-0.0088	-0.0260	0.1426**	-0.1781	-0.0461
Elkhart	0.0045	-0.0880*	-0.0343	0.0152	-0.0107	-0.0066	0.1446**	-0.1680	-0.0525
Wabash									
Mt. Vernon	0.1318	-0.0226	-0.0067	0.0254	0.0032	-0.0319	0.1081*	-0.1444	-0.0262
West Southwest									
Altamont	0.0924	-0.0562	-0.0167	0.0267	-0.0016	-0.0096	0.1390*	-0.1801	-0.0371
Carlinville	0.0457	-0.0703	-0.0342	0.0153	-0.0091	-0.0314	0.1441**	-0.1570	-0.0468
Nashville	0.1332	-0.0350	-0.0140	0.0289	0.0024	-0.0328	0.1398**	-0.1546	-0.0257
Little Egypt									
Benton	0.1404	-0.0090	0.0043	0.0381	0.0074	-0.0256	0.1245*	-0.1875	-0.0279

Annual observations = 27. ***, **, * denote statistical significance at the 1%, 5%, 10% level, respectively. For positive entries, H_0: *The mean difference ≤ 0* and H_a: *The mean difference > 0*. For negative entries, H_0: *The mean difference ≥ 0* and H_a: *The mean difference < 0.*