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EVIDENCE FOR A WEATHER PERSISTENCE EFFECT ON THE CORN, WHEAT AND SOYBEAN GROWING SEASON PRICE DYNAMICS

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I. INTRODUCTION

The growing season weather in the corn, wheat and soybean production areas of the United States is an important determinant of the U.S. supply of these commodities. The weather and climatology literature strongly suggest that during the summer months there is a degree of persistence in the North American weather patterns. Given this nonrandom character of weather and given that the corn, wheat and soybean belts are geographically concentrated enough to be dominated by a regional weather phenomenon, their futures markets are hypothesized to reflect this assimilation of nonrandom weather information as nonrandom price fluctuations. An empirical test of this question is the subject of this paper.

II. THE GROWING SEASON

Most corn in the U.S. corn belt states is planted in May and harvested in October and November. Numerous studies point to midwestern weather conditions in the June through August period as being especially important determinants of national corn yields. See Teigen and Singer (1988), Ash and Lin (1987), Vroomen and Hanthorn (1986), Van Meir (1984) and Lin and Davenport (1982). A recent excellent investigation of the subject by Westcott (1989) focuses on planting dates and June and July precipitation and temperature in the corn belt to explain national corn yields.

As noted by Westcott (1989, p. 18), typical daily water use rates for 110 growing day corn peaks at about the 60th day of growth; the largest water use occurs from about the 40th day to about the 80th day. Therefore in the corn belt, corn planted on typical dates in early- to mid-May normally experiences peak utilization of water in late-June and throughout July. Mid-June and early-August water use rates are also high for earlier and later planted corn, respectively. Westcott also notes that temperature plays an important role in crop development, potentially stressing the corn plant at critical stages of crop formation and increasing the evaporation of moisture reserves from the soil.

Soybeans are known to be a more resilient crop, more capable of performing under stress. They have vulnerability in August when the soybeans are flowering and setting and filling pods. In an empirical study of the influence of seasonal weather on soybean yields Willimark and Teigen (1985, p. 28) state:

> "The important weather variables are temperature in June, precipitation in July, and both precipitation and temperature in August...
>
> ... warmer than normal temperatures in June tend to increase yields...
>
> ... Additional rainfall during July results in more flowers being formed and bloomed. In August, the amount of precipitation is critical, affecting the number of pods being formed and determining the size and quantity of beans within those pods..."

But geographically, the corn and soybean belts are largely located in the same place. Therefore, adverse and/or favorable weather usually affects the national corn and soybean crops in a similar way from year to year.

The growing season for wheat is more difficult to define

with precision at the national level. Winter wheat is planted in the fall. Spring wheat is planted in the spring. The harvest season ranges from June in Texas to August in North Dakota. As such, the national wheat crop is more diversified against any persistent weather patterns.

This diversity is illustrated in an empirical study of regional wheat yeilds by Ash and Lin (1986). Six regions are studied: the Northern Plains, the Southern Plains, the Mountain, the Pacific and lake states, and the Corn Belt. Explanitory variables include March through July precipitation and temperature. Although both temperature and precipitation are frequently significant, the signs and level of significance varies substantially from region to region. Ash and Lin (1986, p. 11) in a general statement indicate:

> "Wheat does not require as much precipitation as corn or soybeans. A minimum of 4 inches of soil moisture is necessary to grow winter wheat to the kernal setting stage. An insufficient level can devastate yields. Excessive rainfall during the months of April and May delays spring planting to the point where yields may be more vulnerable to adverse summer conditions. Temperature also affects yields. When heat stresses young plants, they may wither or ripen prematurely with shrunken heads and shriveled grain. This is more of a problem for spring wheat than winter wheat. Warmer springtime temperatures assist the development of fall-sown wheat."

III. PERSISTENCE IN THE WEATHER

In the context of the subject of weather and climate, persistence refers to a regional stability in the weather pattern for a time period. While a thorough review of this literature is outside the scope of this paper, some examples are given to support the view that regional weather patterns can often be persistent. Namias and

Trenberth are prominent in the recent weather persistence literature. Namias (1986) finds and summarizes extensive empirical evidence that North American weather, in terms of flow pattern, temperature and precipitation, is significantly persistent in the winter and summer months with a short period of nonpersistence around or just after the equinoxes. Trenberth, Branstator and Arkin (1988, p. 1643) in an article focused on the origins of the 1988 North American drought state:

> "The evidence suggests that persistent global-scale anomalies in the atmospheric circulation set the stage for the [1988] drought in the United States. Large-scale circulation anomalies have also been associated with earlier U.S. droughts. In summer droughts, there has always been upper-level anticyclonic conditions over the United States, usually associated in a wavelike pattern with a deeper than normal upper-level through along the west coast of North America and another anticyclonic region over the central North Pacific...
>
> In general in summer, once anticyclonic conditions prevail over the United States, other more local factors probably help maintain the droughts and produce heat waves. In particular, land-surface processes involving the absence of soil moisture probably have a significant effect. Normally, heating from the sun is partitioned into evapotranspiration and sensible heating of the surface and atmosphere. But in drought conditions, evaporation and plant transpiration are greatly reduced so that nearly all heating is manifested as temperature increases. Moreover, the absence of moisture conspires against widespread precipitation. Heat waves result and a drought becomes, at least in part, self-perpetuating."

IV. SEASONAL PRICE DYNAMICS

The importance of growing conditions in the late-June through early-July period, accompanied by some potential for the weather influence itself to persist in some fashion, raises an interesting question for corn price dynamics during this period. As stated by Anderson (1985, p. 333):

> "For grains, total annual production is determined by acreage planted and yields. Yields in turn are heavily dependent upon weather conditions at certain times of the growth process. These crucial phases tend to occur at approximately the same times during the calendar year. Consequently, we would expect the resolution of production uncertainty to follow a strong seasonal pattern."

While Anderson's focus is on volatility--seasonal volatility and Samuelson's (1965, 1976) hypothesis that volatility increases as the maturity of a futures contract approaches--this study focuses on the seasonal randomness, or lack thereof, of these prices. Samuelson (1965) introduced the theoretical relationships between random walk and expected returns models in the theory of efficient markets. Previous and subsequent empirical investigation of the market efficiency literature, for the most part, has concluded that the futures markets are in most cases efficient as measured by serial dependence in a time series. Fama (1965, p. 399), after an extensive review of the empirical literature, states:

> "At this date the weight of the empirical evidence is such that economists would generally agree that whatever dependence exists in a series of historical returns cannot be used to make profitable predictions of the future. Indeed for returns that cover periods of a day or longer, there is little in the evidence that would cause rejection of the stronger random walk model, at least as a good first approximation."

On the other hand, there is significant research in the literature that finds exception. For example, Stevenson and Bear (1970, p. 80) in an investigation of corn and soybean serial correlations and analysis of runs, found evidence to "cast considerable doubt on the applicability of this hypothesis to the market for commodity futures." They note similar evidence against the random walk model in the work of Cootner (1964) and Larson (1960).

We also find some evidence that during the growing season corn, wheat and soybean prices do not vary as a random walk. Persistent weather conditions in this important season, we hypothesize, arriving with some degree of momentum as suggested by the weather and climate literature, induce similar momentum into these commodity price dynamics.

To test the question we use simple regression analysis:

(1) P(t,k) = Alpha + Beta*P(t-1,k) + E

where

P(t,k) Change in futures price on day t during season k.

t Ranges from October 1, 1972 through September 30, 1989.

k Ranges across 48 time cells per year defined as the 1st through the 7th, 8th through the 15th, 16th through the 23rd, and 24th through the 31st of each calendar month.

E Randomly distributed error.

The null hypothesis, B = 0, is that during the growing season, the weather persistence does not, in fact, induce momentum into the price dynamics. That is, if P(t-1,k) contains some information about the current state of weather persistence, it does not significantly influence P(t,k). The null hypothesis is rejected during those time periods when Beta is significantly positive.

V. THE DATA BASE

The study focuses on a 17-year period beginning October 1, 1972, and ending September 30, 1989. During this period there were major corn belt droughts during the years 1974, 1980, 1983 and 1988. Significant but more localized droughts in the western corn belt also occurred in 1975, 1976 and 1977.

To achieve continuity across a 17-year time frame, the observed daily price change was drawn from the actively trading nearby futures contracts of Chicago corn, Chicago soybeans and Chicago wheat, according to the schedule in Table I.

TABLE I

OBSERVED FUTURES CONTRACT SCHEDULE FOR
CHICAGO BOARD OF TRADE CORN, SOYBEANS AND WHEAT

Calendar Month	Chicago Board of Trade Futures Contract		
	Corn	Soybeans	Wheat
January	March	March	March
February	March	March	March
March	May	May	May
April	May	May	May
May	July	July	July
June	July	July	July
July	September	September	September
August	September	September	September
September	December	November	December
October	December	November	December
November	December	January	December
December	March	January	March

VI. EMPIRICAL RESULTS

Inspecting Table II we find significantly positive values for Beta tending to cluster in the growing seasons for corn and soybeans. The season defined by May 24 through August 23 stands out with numerous positive t values at the 10 percent level of significance or better. Of the 24 corn and soybean time cells of this period, all but two are positive, and 14 are significantly positive.

These results are in sharp contrast to the statistical character of the corn and soybean market during the rest of the year. Outside of this season we observe 80 time cells, with only 13 containing significantly nonzero Beta values. Moreover, of these 13, eight are negative in sign. The nongrowing season statistical results are clearly more sporadic.

The lack of a cluster of significantly positive values of Beta for wheat suggests that either the wheat growing season has less weather persistence and/or wheat in its growing season is less sensitive to weather than is corn or soybeans. On the former point, Namias (p. 1369) notes a lack of persistence in his data during both the spring and fall equinox period. On the latter point, we speculate that this phenomenon may result in part from wheat generally being a hardier plant. Also at the national level, we would offer that wheat is more geographically diversified, with the three somewhat distinct regions, hard red winter, soft red winter and hard red spring--not to mention durham and white wheat. With the wheat harvest in Texas beginning in June and ending in North Dakota in August, the wheat growth and maturity itself is more diversified across time. As such, wheat is probably more diversified against any persistence that may be present in the weather patterns. Still, the fact that 10 of 12 coefficients are positive during the

TABLE II

A SEASONALLY PARTITIONED STATISTICAL SUMMARY
FOR THE PERIOD OCTOBER 1, 1972 THROUGH SEPTEMBER 30, 1989

	Corn			Soybeans			Wheat		
Time Cell	N	Beta	t	N	Beta	t	N	Beta	t
Jan 1- 7	69	-.19	-1.37	69	-.19	-1.51	69	.27	1.98*
Jan 8-15	96	-.11	-1.19	96	-.03	-.34	96	-.18	-2.03**
Jan 16-23	98	-.02	-.18	98	.09	.92	98	-.08	-.70
Jan 24-31	96	-.01	-.07	96	-.22	-2.22**	96	.00	.00
Feb 1- 7	85	-.02	-.15	85	.02	.15	85	-.13	-1.19
Feb 8-15	94	-.01	-.12	94	-.24	-2.44**	94	.19	1.75*
Feb 16-23	82	.33	2.87**	82	-.06	-.50	82	-.17	-1.54
Feb 24-29	64	.51	3.83**	64	.05	.39	64	.20	1.26
Mar 1- 7	85	-.14	-1.43	85	-.13	-1.30	85	.00	.02
Mar 8-15	97	.06	.59	97	-.11	-1.08	97	-.02	-.16
Mar 16-23	97	-.30	-2.93**	97	-.16	-1.53	97	-.05	-.45
Mar 24-31	93	-.10	-1.08	93	.15	1.48	93	.08	.71
Apr 1- 7	81	-.06	-.51	81	.02	.14	81	.04	.34
Apr 8-15	93	-.05	-.52	93	-.02	-.19	93	.13	1.19
Apr 16-23	92	-.07	-.64	92	-.01	-.09	92	.02	.18
Apr 24-30	85	.01	.09	85	.05	.38	85	.10	.87
May 1- 7	84	.08	.74	84	.25	2.69**	84	.06	.61
May 8-15	97	.05	.49	97	-.01	-.14	97	-.09	-.81
May 16-23	98	-.03	-.28	98	.01	.06	98	.11	1.21
May 24-31	80	.07	.55	80	.27	2.27**	80	.01	.05
Jun 1- 7	85	.44	4.01**	85	.74	6.87**	85	-.02	-.18
Jun 8-15	97	.22	2.30**	97	.04	.45	97	.14	1.31
Jun 16-23	97	.30	3.08**	96	.29	3.03**	97	.08	.79
Jun 24-30	85	-.19	-1.65	84	-.07	-.55	85	-.07	-.61
Jul 1- 7	68	.19	1.49	68	.34	3.59**	68	-.09	-.80
Jul 8-15	97	.13	1.30	97	.21	2.15**	97	-.17	-1.74*
Jul 16-23	97	.08	.76	97	.41	4.39**	97	-.09	-.89
Jul 24-31	97	.33	3.25**	97	.22	2.14**	97	-.09	-.88
Aug 1- 7	85	.19	1.81*	85	.27	2.69**	85	.14	1.23
Aug 8-15	98	.04	.41	98	.13	1.16	98	.24	2.37**
Aug 16-23	97	.14	1.46	97	.26	2.79**	97	-.05	-.55
Aug 24-31	97	-.04	-.41	97	-.14	-1.49	97	-.25	-2.48**
Sep 1- 7	68	.18	1.49	68	.03	.27	68	.00	-.01
Sep 8-15	97	-.09	-.96	97	.12	1.17	97	-.19	-1.86*
Sep 16-23	97	.04	.37	97	.04	.36	97	-.17	-1.70*
Sep 24-30	84	.12	1.12	84	.17	1.58	85	.20	1.79*
Oct 1- 7	85	-.25	-2.35**	85	.06	.58	85	-.21	-1.97*
Oct 8-15	96	-.02	-.20	96	.20	1.94*	96	-.03	-.30
Oct 16-23	97	.01	.10	97	.13	1.29	97	.02	.24
Oct 24-31	98	.08	.72	98	-.21	-2.10**	98	.17	1.74*
Nov 1- 7	79	-.04	-.35	79	.12	1.12	79	-.04	-.37
Nov 8-15	97	.14	1.36	97	.01	.10	97	-.01	-.11
Nov 16-23	92	.13	1.34	92	.04	.39	92	-.12	-1.31
Nov 24-30	73	.06	.50	73	-.07	-.58	73	.02	.13
Dec 1- 7	85	-.27	-2.51**	85	-.24	-2.21**	85	-.09	-.87
Dec 8-15	97	.08	.76	97	.20	1.95*	97	.10	.94
Dec 16-23	97	-.13	-1.35	97	-.19	-2.18**	97	-.17	-1.86*
Dec 24-31	73	-.05	-.47	73	.03	.19	74	.07	.55

* Significant at the 10% level, two tail test.
** Significant at the 5% level, two tail test.

March 24 through June 23 period does suggest that there may be a weak weather influence underlying this period, a period that is a reasonable approximation of the wheat growing season.

Table III presents more aggregated statistical results that focus on the growing seasons of each of the three crops versus the rest of the year and the total sample. Price momentum is especially significant in corn and soybeans in the growing season defined by May 24 through August 23 with t values of 5.71 and 8.58, respectively. A split aggregation into two nongrowing season periods, January 1 through May 23 and August 24 through December 31, shows essentially random price motion during these periods. Note that the growing season influence is strong enough to demonstrate significant results at the total data level in corn and soybeans.

In wheat, aggregation across the March 24 through June 23 period discussed above results in significantly positive results with a t value of 2.34. A lower value of Beta for wheat during its growing season at .07 versus .17 for corn and .25 for soybeans reinforces our view that the weather is less persistent during this season and/or the national wheat crop is more spatially and temporally diversified against any persistent weather influence. Like corn and soybeans, the nongrowing season price dynamics appear to be essentially random. Contrary to the corn and soybean results, the growing season influence is not strong enough to create significant results at the total wheat data level.

TABLE III

A SEASONALLY PARTITIONED STATISTICAL SUMMARY
FOR THE PERIOD OCTOBER 1, 1972 THROUGH SEPTEMBER 30, 1989

	Corn			Soybeans			Wheat		
Time Cell*	N	Beta	t	N	Beta	t	N	Beta	t
Period 1	1686	.00	-.15	1686	.00	.11	1657	-.01	-.23
Growing	1083	.17	5.71**	1081	.25	8.58**	1082	.07	2.34**
Period 2	1512	.01	.23	1512	.02	.95	1544	-.04	-1.40
Total	4281	.08	5.11**	4279	.13	8.88**	4283	.00	-.06

* Period 1 is January 1 through May 23 for corn and soybeans and November 1 through March 23 for wheat. The growing season is May 24 through August 23 for corn and soybeans and March 24 through June 23 for wheat. Period 2 is August 24 through December 31 for corn and soybeans and June 24 through October 31 for wheat.

VII. CONCLUSION

We find strong empirical evidence of nonrandom seasonal price dynamics in corn, wheat and soybean futures prices during the period October 1972 through September 1989. The season of the nonrandom price motion aligns well with the growing season of all three commodities. The weather and climatology literature asserts that weather patterns are to some extent persistent in North America during the summer months. We conclude that these nonrandom weather events do transfer a nonrandom influence into these commodity prices during their respective growing seasons.

These results suggest that producers, merchandisers, speculators and others that own these commodities during their respective growing seasons may well benefit from stategies that position on the basis of a perpetuation of price direction.

BIBLIOGRAPHY

Anderson, R. W. (1985): "Some Determinants of the Volatility of Futures Prices," The Journal of Futures Markets, 5:331-348.

Anderson, R. W., and Danthine, J. (1983): "The Time Pattern of Hedging and the Volatility of Futures Prices," Review of Economic Studies, 50:249-266.

Ash, M. S., and Lin, W. (1987): "Regional Crop Yield Response for U.S. Grains," USDA, ERS, AER-577 (September).

____ (1986): "Wheat Yield Response: Policy Implications on Projections," Wheat Situation and Outlook Report, USDA, ERS, WS-275(May):10:16.

Cootner, P. H. (1964): "Comments on the Variation in Certain Speculative Prices," The Random Character of Stock Market Prices, M.I.T. Press, Cambridge.

Fama, E. F. (1970): "Efficient Capital Markets: A Review of Theory and Empirical Work," The Journal of Finance, 25:383-417.

Larson, A. B. (1960): "Measurement of a Random Process in Futures Prices," Food Research Institute Studies, 3:313-324.

Lin, W., and Davenport, G. (1982): "Analysis of Factors Affecting Corn Yields: Projections to 1985," Feed Outlook and Situation, USDA, ERS,
FdS-285(May):9-14.

Namias, J. (1986): "Persistence of Flow Patterns Over North America and Adjacent Ocean Sectors," Monthly Weather Review, 114:1368-1383.

Samuelson, P. A. (1965): "Proof That Properly Anticipated Prices Fluctuate Randomly," Industrial Management Review, 6:41-49.

____ (1976): "Is Real-World Price a Tale Told by the Idiot of Chance," Review of Economics and Statistics, 58:120-123.

Stevenson, R. A., and Bear, R. M. (1970): "Commodity Futures: Trends or Random Walks?" Journal of Finance, 25:65-81.

Teigen, L. D., and Singer, F. (1989): "Weather in U.S. Agriculture: Monthly Temperature and Precipitation by State and Farm Production Region, 1950-88," USDA, ERS, SB789(November).

Trenberth, K. E., Branstator, G. W., and Arkin, P. A. (1988): "Origins of the 1988 North American Drought," Science, 242(December 23):1640-1645.

Van Meir, L. (1984): Feed Outlook and Situation Report, USDA, ERS, FdS-294 (September):4-5.

Vroomen, H., and Hanthorn, M. (1986): "1986-88 Corn Yield Projections for the 10 Major Producing States," Feed Situation and Outlook Yearbook, USDA, ERS, FdS-301(November):15-21.

Westcott, P. C. (1989): "An Analysis of Factors Influencing Corn Yields," Feed Outlook and Situation Report, USDA, ERS, FdS-310(May):16-22.

Willimack, D. K., and Teigen, L. D. (1985): "Regional Soybean Yields," Oil Crops Outlook and Situation Report, USDA, ERS, OCS-7(May):27-31.