1996

Wheat Futures Price Behavior: Empirical Issues For Intramarket Contracts

Dawn D. Thilmany
Utah State University

Jau-Rong Li
Utah State University

Christopher B. Barrett
Utah State University

Follow this and additional works at: https://digitalcommons.usu.edu/eri

Recommended Citation
https://digitalcommons.usu.edu/eri/77
WHEAT FUTURES PRICE BEHAVIOR: EMPIRICAL ISSUES FOR INTRAMARKET CONTRACTS

by

DAWN D. THILMANY
JAU-RONG LI
and
CHRISTOPHER B. BARRETT

Department of Economics
Utah State University
3530 University Boulevard
Logan, UT 84322-3530

June 1996
WHEAT FUTURES PRICE BEHAVIOR: EMPIRICAL
ISSUES FOR INTRAMARKET CONTRACTS

Dawn D. Thilmany, Assistant Professor
Jau-Rong Li, Graduate Student
Christopher B. Barrett, Assistant Professor

Department of Economics
Utah State University
3530 University Boulevard
Logan, UT 84322-3530

The analyses and views reported in this paper are those of the author. They are not necessarily endorsed by the Department of Economics or by Utah State University.

Utah State University is committed to the policy that all persons shall have equal access to its programs and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation.

Information on other titles in this series may be obtained from: Department of Economics, Utah State University, 3530 University Boulevard, Logan, Utah 84322-3530.

Copyright © 1996 by Dawn B. Thilmany, Jau-Rong Li, and Christopher B. Barrett. All rights reserved. Readers may make verbatim copies of this document for noncommercial purposes by any means, provided that this copyright notice appears on all such copies.
This study analyzes the time-series statistical properties of wheat futures prices to determine whether price behavior differs among intramarket contracts. We argue that the differential role of inventories, information, hedging objectives, and probability of stock-out across seasons provide a theoretical basis and empirical interest for finding such a difference. The behavior of May and September futures prices are indeed found to be significantly different and in ways consistent with theory. Furthermore, an endogenous contract arrival effect is found for both contracts, demonstrating the importance of developing models which incorporate market activity proxies.
Introduction

Current theoretical methods of commodity price determination emphasize the importance of storage in transmitting price shocks across periods. Nonetheless, these models do not completely explain the actual behavior of prices (Deaton and Laroque 1992; Blank 1989). Because storage and shocks have significantly different roles in price determination over the year, one might expect variations in price behavior among month-specific contracts. That is the focus of this study. In short, this paper conceptualizes intramarket differences implied by theoretical models of commodity price behavior, empirically tests the hypotheses raised by such analysis, and compares and contrasts the findings to technical trading schemes to address these objectives. We focus on the behavior of wheat futures prices, using five years' daily data.

The paper is divided into four sections. First, we briefly review the literature on storage, commodity prices, and futures price behavior. Second, a conceptual model is used of why differential price behavior is expected among intramarket contracts. Third, we present methodology and empirical results of the price analysis conducted on September and May wheat futures price series. Fourth, we briefly compare these results to charting methods developed by technical analysts. This paper also serves as a starting point for conceptualizing potential time-series econometric issues related to modeling futures prices in a manner consistent with the underlying theory of storable commodities. However, the main purpose of this paper is to empirically analyze how commodity prices vary among seasonal contracts (referred to as intramarket contracts from this point forward).
Futures Price Behavior

Price analysis has been an essential component of futures markets research. The literature reveals two important findings about futures price series. First, the unconditional distribution of most futures returns is leptokurtic (Hall, Brorsen, and Irwin 1989), i.e., exhibits fatter tails than would be found in a normal distribution. This reflects a higher probability of extremely high or low returns. Second, most futures returns are conditionally heteroscedastic (Fujihara and Park 1990; Yang and Brorsen 1995), implying that current price variability can be explained by past information. Given the nature of commodity markets, these statistical properties may be explained theoretically, as has been the case with cash prices.

Although it has been shown that cash prices are affected by storage, it is not certain that the same effects would be found in futures price series. Research on the effects of storage on futures prices has been limited in scope. Empirical tests of the “accuracy” of futures markets' response to information (including stock volumes) have sought to identify bias in the pricing process, mostly focusing on an analysis of backwardation. Three traditional explanations for the backwardation present in futures prices have developed in the futures literature: that the future is discounted relative to the present; convenience yield (Kaldor 1939); and finally, that futures prices are downward-biased by the risk premia afforded agents who are allowed to lock in prices.

Convenience yield studies seek to explain differences in futures price behavior across seasons based on the concept that agents have an incentive to store inventories locally when aggregate stocks are low. The convenience yield hypothesis pertains to any stored good regardless of the frequency of its production and as Frechette summarizes, “at one extreme, an agricultural commodity may be harvested annually and stored through the year; at the other
extreme, a metal may be continuously mined and refined.” Witt et al. (1987) analyzed differences in optimal hedge ratios across contracts but did not pursue the reasons why such differences exist. The expected differences in intramarket price behavior is the motivation for the analysis of September and May contracts in this study. It will be argued here that differential price behavior among these contracts is related to primary structural factors which are of general importance to all veins of futures market research.

Williams and Wright (1991) posit another theory to explain the relationship between cash and futures price behavior based on the probability of stock-out and nonnegativity constraints on stocks. If future spot prices are expected to increase, locking into a futures price is not as attractive an option for hedgers or speculators. Thus, futures prices are downward-biased. However, this would only happen in certain market conditions, since high current levels of stocks may signal that future spot prices will not be significantly increasing. This theory lends support to the hypothesis of differential impacts of storage across intramarket contracts, since the probability of stock-out varies across the year, especially in crops such as wheat which are dominated by one annual harvest.

Technical trading is based on the belief and ability of analysts to find and exploit patterns and formations in price series that allow them to profit from such analysis. However, these practitioners take a very different approach than do academic economists to understanding price behavior, concentrating on some market fundamentals, as well as market perceptions, or the psychology of trading (CTS 1996). As would be expected, many of the traditional formations found in technical charting analysis are consistent with the expected statistical properties of
commodity futures prices. This offers an interesting comparative analysis for this study, one which we briefly explore in the penultimate section.

**The Role of Storage in Price Determination**

Inventories were first incorporated into models of spot and futures price behavior by Williams (1935). He demonstrated that expected prices should follow an upward-climbing path whenever stocks are held using the Hotelling rule (1931). It follows that futures prices are rational expectations of future spot prices in a risk-neutral market. Yet, the actual behavior of prices seem more complex.

The role of storage in price determination has been addressed primarily from an empirical perspective (Stein 1961), including studies analyzing the convenience yield and any effects that inventories may have on expected price levels. The seasonal nature of inventory levels on futures markets, called the inventory effect, provides a benchmark for the theoretical argument made in this study about varying price behavior among intramarket contracts. Lien (1987) found no conclusive results for the “inventory effect” in corn or wheat futures markets, lending support to the hypothesis of year-round, efficient markets. He tested this inventory hypothesis by analyzing whether seasonal changes in inventory levels create potential for profitable price changes, i.e., $\mathbb{E}(P_{t+1}) \neq P_t$. However, the higher-order statistical properties of futures prices as they relate to inventory levels have not been analyzed and may better explain how storage affects intramarket commodity price behavior. These factors are the focus of this study.

Working (1949) made the first attempt to explain commodity prices in terms of a simple theory based on storage. He focused attention on the role that storage plays in transferring
commodities from relatively plentiful times to relatively scarce times, and how this affects price behavior. More recently, Deaton and Laroque (1992) noted that theory of the determination of commodity prices, although well-developed, cannot explain the actual behavior of prices. Their theory of price behavior, like Williams and Wright's (1991), follows a traditional supply and demand approach with explicit attention to the role of inventories on speculative agents' expectations. They found that a standard rational expectations competitive storage model of commodity prices can explain a number of the data's statistical properties, including skewness, and the existence of rare but violent explosions in prices, coupled with a high degree of price autocorrelation in more stable periods. Their approach is the theoretical basis for this study.

In short, Deaton and Laroque (1992) analyzed prices as a function of potential stock-outs. The nonnegativity constraint inherent to grains storage implies asymmetry in storable commodities' price distributions. In effect, this introduces a nonlinearity to the system which can be thought of as establishing a threshold price as a lower bound for futures prices but no similar upper bound constraining prices. Thus, one would expect positive skewness and higher variance in prices as prices increase. Conversely, with no potential for negative inventories, conditional variance, and skewness should fall with prices. Thus, the variance and skewness of next period's price distribution are nondecreasing functions of current price. In general, prices spend long periods at low, stable levels, showing little movement but high autocorrelation from year to year. Once a high price emerges, precipitating a high probability of further high prices due to autocorrelation, the probability of stock-out rises, resulting in the peaks found in commodity price series.
Storage permits the intertemporal transmission of shocks to conditional price distributions. Where stocks are always positive, there should be considerable price autocorrelation, persistence of shocks, and autoregressive conditional heteroscedasticity (ARCH). However, there should not be discernable conditional skewness in series so long as ample stocks remain on hand. However, when stocks dwindle, i.e., stock-outs occur, ARCH effects should diminish and positive price spikes (i.e., skewness) should appear.

The Deaton and Laroque (1992) and Williams and Wright (1991) models are based on the idea that the probability of stock-outs, \( \Pr_t(\text{Stock-out}_{t+1} | \Phi_t) \), is directly related to current inventories on hand and the current level of prices \( (P_t, I_t \in \Phi_t) \). First, the basic effect of storage on price behavior is defined as,

\[
\frac{\partial \Pr_t(\text{Stock-out}_{t+1}|F_t)}{\partial I_t(P_t)} < 0 ,
\]

where \( I_t \), inventories at time \( t \), is itself a function of current prices. In particular,

\[
\frac{\partial I_t}{\partial P_t} < 0 ,
\]

if speculative storers maximize profits. This implies that,

\[
\frac{\partial \Pr_t(\text{Stock-out}_{t+1})}{\partial (P_t)} > 0 .
\]

Because storage permits intertemporal trade, it increases the price elasticity of supply. Stock-outs reduce storage by definition, thereby dampening supply elasticity and leading to greater price variability in the face of demand shocks. Given the relationship between current prices and the probability of future stock-out, these effects yield asymmetric price shocks. Mathematically, we posit that
where \( \sigma^i \) is the \( i \)th central moment of the price distribution. Recognizing the relationship in (3), this suggests that

\[
\frac{\partial \sigma^i_{t+1}}{\partial \operatorname{Pr}(\text{Stock-out}_{t,i})} > 0 \quad \text{for } i = 2, 3, 4
\]

The conceptual basis for this study is the hypothesis that futures prices will be similarly affected by the probability of a stock-out and, thus, the level of storage of a commodity and its current price. However, information on, and perceptions of, stock levels vary throughout the year, prompting our interest in empirical analysis of intramarket contracts.

**Intramarket Contract Analysis**

The role storage plays in price determination may vary over time whenever commodity supply depends on a periodic harvest, annually in the case of wheat. Thus, a wheat contract maturing in the spring may exhibit different price behavior than a wheat contract maturing in the fall. If storage was plentiful and the demand for futures contracts was reasonably uniform throughout the year, one would expect quite similar price patterns in futures contracts maturing at different times of the year. But, when market supply is dominated by an annual harvest, such as is the case with wheat, and competitive storage does not always ensure sufficient positive inventories, there may be important intramarket pricing differences.

Moreover, demand for futures contracts plays a role. Thus, we test for an endogenous contract arrival effect, which measures whether relatively early market activity on the coming
year's futures contract (a proxy for demand of futures contracts) affects price levels. To test for such an effect, a structural variable (TRUN) was added into the econometric model, where TRUN was the number of days remaining in the maturing contract when the next year's contract became active. The opposite method of truncation, truncating the new contract prices until the current contract matured, yielded qualitatively similar time-series results with the exception of insignificant TRUN variables. However, the former method was eventually used because we argue that a relatively earlier truncation would allow us to more fully capture the interyear effects of both price behavior and the contract arrival effect.\(^2\)

The September and May contracts may have different price behavior for several reasons: the varying role of informational shocks, storage levels, and trading volumes throughout the year. Understanding intramarket differences has practical importance as well. For one, producers hedging with the futures market to mitigate price risk will tend to use one specific contract delivery month, depending on their marketing strategy. These agents need information on the price behavior of particular contracts, not the synthetic nearby contract price series commonly studied by academics. Similar arguments could be made for elevators which hedge their expected supplies, livestock producers who hedge feed supplies, and processors who hedge input supply commodities at particular times of the year.

Another economic factor which varies across time is inventory levels and, thus, the transactions costs of using the cash vs. futures market to determine prices. The primary seasonal effect evident with commodities is the "lumpiness" of the production process. In the case of many commodities, including wheat, the vast majority of supply is based on a once-a-year harvest. Regardless of the average grain stocks for a year, there will always be higher inventory levels
immediately following harvest than for 6 months later. Thus, prices on futures contracts with different maturity or delivery dates are affected by very different perceptions about the probability of a stock-out. As conceptualized above, the probability of a stock-out not only will be influenced by the absolute level of prices, but also by potential replenishment of stocks, in this case, the next annual harvest. The same argument would hold true with respect to the relationship between variability of prices and potential stock-outs. Thus, because the underlying wheat inventories are markedly different in these months, so should one expect the conditional futures price distributions to differ between May and September contracts. In particular, because September inventories are always considerable, we will expect a near-zero probability of stock-out and, thus, GARCH effects without positive residual skewness. In May, however, the opposite is true of inventories, and one would expect residual skewness without GARCH effects.

Williams (1987) concluded that backwardation exhibited in futures markets is because they are used as an instrument to determine approximate cash prices in order to lessen the transaction costs inherent in the cash market. It could be argued that the value of this function fluctuates based not only on market conditions but also by the time of the year. The cash market transactions costs for a producer selling a commodity already in storage is arguably less than for a producer trying to market a crop which is still not available for delivery. This concept further supports our hypothesis about differential intramarket futures market behavior.

Finally, pertinent information availability varies predictably over the course of the trading year, which influences perceptions of the probability of stock-out as well. This lends further support to the idea of intramarket differentials in price behavior. In general, a spring wheat contract (especially the last half of the contract period) trades on known supply since only
inventoried stocks are available for consumption prior to the next harvest. The fall wheat contract, in contrast, is more directly affected by information about the incoming supply levels (as determined by periodic crop reports). In short, information on the quantity of replenishment stocks will vary greatly throughout the year as the planting, growing, and harvest seasons progress.

Empirical Analysis

We studied Chicago Board of Trade data on soft red winter wheat futures contract prices determined at the closing of each trading day. Both the May and September futures contract prices in our analysis run from January 1990 to October 1995. Casual visual analysis of these price series (Figures 1a and 1b) reveals standard patterns: significant autocorrelation and long

![Figure 1a. Daily closing futures prices of May contract.](image-url)
Figure 1b. Daily closing futures prices of September contract.

periods of fairly stable prices punctuated by occasional positive spikes and extraordinary volatility in prices.

The descriptive statistics in Table 1 reveal several of the price characteristics predicted by the conceptual model. Both the May and September contract prices exhibit substantial autocorrelation between daily prices. The coefficients of variation show that the two price series are not especially volatile. The persistence, a measure of how long exogenous shock will persist into the indefinite future, is relatively low for both contracts, indicating that shocks' effects dissipate in the medium term. Finally, the last two columns present the relative skewness and kurtosis of the unconditional price distributions, which one generally compares to the standard normal distribution values of 0 and 3, respectively. The September contract has positive skewness and substantial kurtosis, with tails much fatter than those of the normal distribution,
Table 1. Descriptive Statistics

<table>
<thead>
<tr>
<th></th>
<th>Autocorrelation (days)</th>
<th>Coeff. of Persistence</th>
<th>Relative Skewness</th>
<th>Relative Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>May</td>
<td></td>
<td>0.992</td>
<td>0.984</td>
<td>0.977</td>
</tr>
<tr>
<td>Sept</td>
<td></td>
<td>0.993</td>
<td>0.987</td>
<td>0.981</td>
</tr>
</tbody>
</table>

Note: Persistence is the normalized spectral density at zero. The relative skewness measure is \( \frac{\mu_3}{(\mu_2)^{1.5}} \), and the relative kurtosis measure is \( \frac{\mu_4}{(\mu_2)^2} \), where \( \mu_i \) is the \( i \)th central moment.

however, neither of these conditions are found in the May contract. These findings are basically consistent with other studies, like Deaton and Laroque (1992).

Time-series can be modeled with an autoregressive integrated moving average (ARIMA) specification to control for the high levels of autocorrelation and potential nonstationarity inherent in high frequency time-series data. First, we tested for stationarity in the data series using the augmented Dickey-Fuller (ADF) unit root test. The ADF t-statistics of -1.85 and 0.13 for the original May and September logs of prices, respectively, supported the rejection of a unit root in those series at the 1% significance level. The ADF t-statistics for the first-differences in the logs of May and September prices were -17.49 and -16.69. Thus, both the May and September price series were found to be integrated of order one in their logarithms. Further analysis is thus based on the first-differenced log series (\( \Delta \ln P \)).

The next step involved identifying the time-series dimensionality of the stationary \( \Delta \ln P \) series. We used Akaike's (1981) information criterion (AIC). In both May and September contracts, we found lags of up to five days in both the dependent variable and the residuals were significant, so we estimated an ARIMA (5,5) model. We used the Ljung-Box-Pierce portmanteau
Q-statistic to confirm that the residuals from this ARIMA specification follow a white noise process.

Given the volatility clustering apparent in the plotted prices, we next tested for GARCH effects using the Q-statistic on the squared residuals. GARCH processes admit volatility clustering and, thus, some leptokurtosis to financial futures price series (Bollerslev 1986), and appear useful to commodity futures price analysis as well (Myers 1994). Where we found GARCH effects, we identified the time-series dimensionality of the conditional variance following Bollerslev (1988). We then verified these GARCH specifications by a Q-test of the squared normalized residuals, $v_t$. We thus model the data-generating process of wheat futures price as

\[ \Delta \ln p_t = x_t \phi + e_t \]

\[ e_t = v_t \sqrt{h_t} \quad \text{where } v_t \sim N(0, 1) \]

and,

\[ h_t = \alpha_0 + \sum_{i=1}^{q} \beta_i e_{t-i} + \sum_{i=1}^{p} \gamma_i v_{t-i} + \gamma z_t, \]

where $x_t$ is a vector of predetermined variables which may include lagged dependent variables and lagged residuals, $\phi$ is the corresponding vector of parameters. $e_t$ is the disturbance term, which follows a normal distribution with mean zero and conditional variance $h_t$. The $z_t$ variable permits the inclusion of structural explanatory variables in the conditional variance equation (8).

Finally, $x_t$ and $z_t$ include a structural variable, TRUN, representing the endogenous contract arrival effect. To properly join several years of contract data together, there needed to be a point each year where the data set rolled over from the maturing year’s to the next year’s contract. Thus, the number of truncated days was included as a regressor on the day when the rollover occurred; TRUN takes the value of zero all other days. Not only does this control for the
time-series shock of the truncation, but it determines whether there is a predictable effect on the price behavior for these contracts as they roll over from one year to the next. In particular, this tests for market demand, since the number of days truncated indicates how early a critical mass of demand emerged for the new contract. We label this an endogenous contract arrival effect. One possible shortcoming of the test for endogenous contract arrival effects relates to the degrees of freedom available for each contract. With only five years of data, only four “rollover” days exist. However, there is an interesting qualitative point to be made from the variability in truncated days. The May contract’s truncation period was relatively consistent with 44, 39, 41, and 40 days, respectively, whereas the September contract’s truncation periods were 34, 125, 41, and 15 days, respectively. This intramarket variability in the temporal onset of market activity reinforces our intuition of significant intramarket behavioral differences.

**Empirical Findings**

Table 2 presents our findings.³ For the May contract, all of the conditional mean equation variables—the ARMA (5,5) coefficients as well as that on the truncation variable—were significant. The significant and positive TRUN variable indicates that the percentage change in prices will increase with the number of days truncated from the maturing contract. At the mean value of 41 days truncated, this represents only a 0.2% stimulus to prices, which persists due to nonstationarity in the price levels. The Box-Pierce Q-statistics for the $e_t^2$ indicate there are no GARCH effects present in the May contract (although significant heteroscedasticity does exist). Moreover, significant positive skewness remains in the residuals. These are precisely the characteristics one would predict for a contract subject to real risk of inventory depletion.
Table 2. ARIMA (5,1,5) Results for May Contract

<table>
<thead>
<tr>
<th>Dependent Variable: Δ ln P</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-1.75E-5</td>
<td>-0.0611</td>
</tr>
<tr>
<td>TRUN</td>
<td>4.33E-04</td>
<td>3.1115*</td>
</tr>
<tr>
<td>AR(1)</td>
<td>0.2722</td>
<td>3.7336*</td>
</tr>
<tr>
<td>AR(2)</td>
<td>-0.3576</td>
<td>-13.0268*</td>
</tr>
<tr>
<td>AR(3)</td>
<td>0.1071</td>
<td>4.0047*</td>
</tr>
<tr>
<td>AR(4)</td>
<td>0.3188</td>
<td>9.5275*</td>
</tr>
<tr>
<td>AR(5)</td>
<td>-0.5693</td>
<td>-8.5446*</td>
</tr>
<tr>
<td>MA(1)</td>
<td>-0.2472</td>
<td>-3.5857*</td>
</tr>
<tr>
<td>MA(2)</td>
<td>0.3042</td>
<td>17.9863*</td>
</tr>
<tr>
<td>MA(3)</td>
<td>-0.1344</td>
<td>-9.7736*</td>
</tr>
<tr>
<td>MA(4)</td>
<td>-0.3761</td>
<td>-12.0227*</td>
</tr>
<tr>
<td>MA(5)</td>
<td>0.5576</td>
<td>8.3098*</td>
</tr>
<tr>
<td>F-statistic</td>
<td>3.173*</td>
<td>p-value = 0.0002</td>
</tr>
<tr>
<td>Box-Pierce Q for ε₁&lt;sub&gt;t&lt;/sub&gt;</td>
<td>9.0839</td>
<td>p-value = 0.982</td>
</tr>
<tr>
<td>Box-Pierce Q for ε₂&lt;sub&gt;t&lt;/sub&gt;</td>
<td>7.4300</td>
<td>p-value = 0.995</td>
</tr>
<tr>
<td>Jarque-Bera statistic</td>
<td>10764</td>
<td>p-value = 0.000</td>
</tr>
<tr>
<td>Skewness*</td>
<td>0.671</td>
<td>p-value = 0.000</td>
</tr>
<tr>
<td>Kurtosis*</td>
<td>17.055</td>
<td></td>
</tr>
<tr>
<td>B-P-G test ‡</td>
<td>618.65</td>
<td>p-value = 0.000</td>
</tr>
</tbody>
</table>

Notes: †For the May price series, all diagnostic tests are performed on the errors, ε₁<sub>t</sub>.  
‡Breusch-Pagan-Godfrey (Breusch and Pagan 1979) test for heteroscedasticity.

The same ARMA model was estimated for the first-differenced log prices on the September contract (Table 3). In contrast to May contract prices, the autocorrelation in September contracts comes with several days’ lag. Moreover, GARCH effects are evident in the September series, but there is no positive skewness in the (v<sub>t</sub>) residuals. Indeed, skewness is negative and statistically significantly different from zero. The coefficient on the TRUN variable in the conditional mean equation was again positive and significant. At the mean truncation value
Table 3. The GARCH (3,2) Results for September Contract

<table>
<thead>
<tr>
<th>Dependent Variable: Δ ln P</th>
<th>Coefficient</th>
<th>t-statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conditional Mean:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.000362</td>
<td>0.8237</td>
</tr>
<tr>
<td>TRUN</td>
<td>0.0002759</td>
<td>5.8320*</td>
</tr>
<tr>
<td>AR(1)</td>
<td>-0.1018</td>
<td>-0.4457</td>
</tr>
<tr>
<td>AR(2)</td>
<td>-0.3017</td>
<td>-1.5200</td>
</tr>
<tr>
<td>AR(3)</td>
<td>-0.1717</td>
<td>-0.8856</td>
</tr>
<tr>
<td>AR(4)</td>
<td>0.5399</td>
<td>3.3570*</td>
</tr>
<tr>
<td>AR(5)</td>
<td>-0.4138</td>
<td>-2.5750*</td>
</tr>
<tr>
<td>MA(1)</td>
<td>0.1098</td>
<td>0.4676</td>
</tr>
<tr>
<td>MA(2)</td>
<td>0.2494</td>
<td>1.2720</td>
</tr>
<tr>
<td>MA(3)</td>
<td>0.1128</td>
<td>0.6595</td>
</tr>
<tr>
<td>MA(4)</td>
<td>-0.5502</td>
<td>-3.6750*</td>
</tr>
<tr>
<td>MA(5)</td>
<td>0.3906</td>
<td>2.4020*</td>
</tr>
<tr>
<td><strong>Conditional Variance:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRUN</td>
<td>-0.7175E-10</td>
<td>-0.1973E-03</td>
</tr>
<tr>
<td>α₀</td>
<td>0.3174E-05</td>
<td>3.2220*</td>
</tr>
<tr>
<td>α₁</td>
<td>0.2324</td>
<td>5.3710*</td>
</tr>
<tr>
<td>α₂</td>
<td>-0.2036</td>
<td>-4.1880*</td>
</tr>
<tr>
<td>α₃</td>
<td>-0.0205</td>
<td>-0.8625</td>
</tr>
<tr>
<td>β₁</td>
<td>0.963</td>
<td>11.5600*</td>
</tr>
<tr>
<td>β₂</td>
<td>0.003879</td>
<td>0.0491</td>
</tr>
<tr>
<td>Box-Pierce Q for ν₁</td>
<td>7.2719</td>
<td>p-value = 0.996</td>
</tr>
<tr>
<td>Box-Pierce Q for ν₂</td>
<td>0.0112</td>
<td>p-value = 1.000</td>
</tr>
<tr>
<td>Jarque-Bera statistic</td>
<td>1285.4980</td>
<td>p-value = 0.000</td>
</tr>
<tr>
<td>Skewness*</td>
<td>-0.1310</td>
<td></td>
</tr>
<tr>
<td>Kurtosis*</td>
<td>7.8721</td>
<td></td>
</tr>
<tr>
<td>B-P-G test</td>
<td>1302.00</td>
<td>p-value = 0.000</td>
</tr>
</tbody>
</table>

Note: †For the September price series, all tests are performed on the normalized errors, νₙ.
of 54 days, this represents a 1.5% increase in mean price, nearly an order of magnitude greater than the endogenous contract arrival effects on March prices. These findings are consistent with our interpretation of early contract arrival representing a demand-side effect. Interestingly, this variable has no significant effect on conditional variance.

As expected, there are significant differences in price behavior among the two contracts. The May contract exhibits the positively skewed residuals one expects when there is a positive probability of stock-out. The September contract does not. Instead, it exhibits GARCH effects associated with the intertemporal transmission of price volatility due to storage. March contracts have no GARCH effects. Both models’ errors remain heteroscedastic and nonnormal, a finding that motivates future research to explore the structural determinants of the higher-order moments of these price series, including capturing asymmetry. Substantial research has been conducted on how to correct for leptokurtosis, but surprisingly little published work has attended to econometric estimation of the positive skewness. This is especially relevant for agriculture, as skewness is to be expected in the prices of storable commodities subject to stock-out.

The endogenous contract arrival effect was a significant explanatory variable in both intramarket contract price series. This clearly needs further analysis since the degrees of freedom on this variable were limited in this study. The empirical findings suggest the value of including market activity proxies and, more generally, structural variables to commodity price analysis.

Implications for Technical Trading Analysis

The literature on futures markets has been somewhat dichotomous. Academic researchers have focused on futures market behavior as it relates to efficient markets theory. Meanwhile,
industry researchers have focused on technical analysis and on formulating methods for short-term financial gains from futures markets. Since technical methods rarely have a theoretical justification and, in fact, contradict the efficient market hypothesis, they have been virtually ignored by academic researchers. Yet, Blank (1989) points out that technical systems are widespread in the trade literature and have value to industry analysts. The commonly found statistical properties in commodity price series may be captured and exploited by technical trading systems. Positive skewness in futures prices may also indicate that information releases and inventory timing lead to asymmetric price responses. For example, the common belief among industry and academic futures researchers that, *What goes up, comes down faster*, implicitly describes the positive skewness modeled by Deaton and Laroque (1992) and Williams and Wright (1991). Academic and industry researchers would most likely gain from further exploring the common basis of their research.

The basis of most technical trading schemes is that trends persist. This concept is inherent to time-series forecasting, which relies on the autocorrelation of prices as the primary explanatory variable of current prices. However, technical trading analysts are most interested in the reversal or correction movements of prices, and their strategies focus on correctly predicting when such market actions will occur. Although it is not defined as such, GARCH processes are the basis for most trading strategies which search for breakouts or reversals depending on the variability of price actions.

Technical traders understand the importance of not only time-series analysis but also structural variables in charting futures prices (CTS 1996), and they have developed increasingly complex charting methods to exploit information contained in such variables. Recently, academic
researchers have taken this as a signal in their research. Lamoureux and Lastrapes (1990) investigated the role of volume as a structural variable in time-series analysis for stock return data to demonstrate that it may explain much of the price behavior captured by ARCH analysis. Yang and Brorsen (1995) likewise integrate structural and time-series regressors. This will be the next step in this research project on intramarket contract analysis.

**Conclusion**

We set out to study the price behavior of two different soft red winter wheat futures contracts (May and September) based on the hypothesis that structural differences in information and storage patterns should cause differences in intramarket contract price behavior. These two price series exhibit many of the same characteristics of long-run commodity price series reported by Deaton and Laroque (1992). There is a high degree of autocorrelation in the price series, just as would be expected in a market where commodity stocks temporally equilibrate interharvest supply and demand conditions. Yet, there are significant differences between the two contracts. The May contract exhibits significant positive skewness but no GARCH effects, while the September contract has GARCH effects without positive residual skewness. Although these empirical findings provide an insight into the differences between intramarket contracts, primarily they highlight the need for further econometric innovation in modeling futures prices. One interesting result from this analysis was the significance of the endogenous contract arrival effect, which measures how early the market emerges for a new contract. The timing of market activity significantly affects price levels, although by only modest amounts and with significant differences
among intramarket contracts. This effect should be of interest to industry analysts concerned about the rollover effects across contracts.

Understanding the statistical behavior of futures market prices is crucial to the development of hedging and futures market policy research. However, it is not always clear that industry and academic researchers are going in the same direction (Blank 1989). Further innovation in the theoretical and empirical modeling of futures prices may go a long way towards bridging the gap between scholarly and business inquiries. Thus, it seems essential for academic researchers to understand more of the trade literature as it could signal other price behaviors which may advance our theoretical and empirical understanding of commodity price behavior.
Bibliography


Notes

* The authors are assistant professor, graduate student, and assistant professor in the Department of Economics, Utah State University, Logan, UT 84322-3530. Seniority of authorship is not assigned. We thank Jeffrey Dorfman, Steven Blank, and NCR-134 1996 Conference participants for helpful comments. This work was supported by the Utah Agricultural Experiment Station and approved as journal paper 4912.

1. Normal backwardation was initially described by Keynes (1921) as a situation in which spot prices are higher than forward prices for a commodity. It is now more frequently used to describe systematic downward-biased estimates of an expected spot price over time.

2. For example, we expect that the next year's contract will be traded earlier if the maturing year's contract exhibits relatively higher prices. Thus, this method allows us to test if, and to what degree, current price behavior affects the demand for the coming year's futures contract. Moreover, the potential for temporal arbitrage should assure similar behavior between the maturing and following year's price behavior.

3. The model was estimated using Shazam 7.0.

4. Dorfman (1993) finds that a large proportion of residuals from agricultural econometric studies are nonnormally distributed. This clearly casts a shadow over maximum-likelihood parameter estimates. But until methods based on more general distributions which permit both kurtosis and skewness (i.e., more flexible than student t-distribution) gain currency, the assumption of normality remains the default.