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The Informational Content of Distant-Delivery Futures Contracts

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Futures markets have two main goals: price discovery and risk management. Because management decisions often have to be made on a time horizon longer than the time until expiration of the nearby futures contract, it is important to determine how well distant-delivery futures contracts are able to assist in price discovery. We focus on soybean and live cattle distant-delivery futures contracts and test for the informational value added to nearby contracts. Two tests for information value provide partially conflicting results due to the different information measures employed. If being able to predict the price trend is sufficient, then we find some information value in distant-delivery futures contracts, while if accurate point estimates of future spot prices are desired the results are negative. Surprisingly, we do not find the expected dichotomy between the storable (soybeans) and non-storable (cattle) commodities.

Key words: distant-delivery contract, futures markets, price discovery

Introduction

One of the main goals of futures markets is price discovery. Price discovery is driven by producers, speculators, processors, consumers, governments, etc. Having accurate forecasts of prices one, three, five, or more months into the future is vital for profitable production decisions, purchases, and planning. Therefore, analyzing futures prices to determine whether distant-delivery contracts contain informational value for price discovery is essential. After all, if distant-delivery futures prices are just random modifications to nearby contracts, then deferred futures are arbitrary and price discovery is ineffective.

Producers and consumers use the risk management feature of futures markets in order to hedge price risk by taking a futures position opposite of their cash market position. Farmers often use distant-delivery futures contracts because of the time to harvest for commodities such as soybeans and the biological lag of livestock such as cattle. For example, a feedlot might use distant-delivery contracts to lock in prices several months before their cattle are ready for market, or on the input side to guarantee the cost of corn for use as feed. Agribusinesses rely on distant-delivery futures to provide accurate forecasts of future input prices and use those contracts to manage their input cost risk through hedging when they deem that appropriate. Speculators play a major role in price discovery and help producers hedge their risk through their willingness to take opposite positions and thus provide liquidity. If futures prices are price forecasts then they provide an estimation of the supply and demand conditions in the future. The question is how far into the future an individual can look to use futures prices and still obtain valuable information. We ask whether or not distant-delivery contracts actually incorporate additional information beyond the nearby contract or are merely random adjustments.

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Henriksson and Merton (1981) proposed a nonparametric test to explore the informational content of any set of forecasts. The Henriksson-Merton test is based on whether a set of forecasts can predict directional changes better than a naïve forecast model. Thus, informational content in futures contracts implies that those futures prices can predict the direction of price movement (increase or decrease) either between the nearby contract's expiration date and now or between a distant-delivery contract's expiration date and a more nearby contract. One could think of the Henriksson-Merton test as a test for the ability to time a market using the information in some set of forecasts; in this application the forecasts are futures prices. Pesaran and Timmermann (1994) modified the Henriksson and Merton test to a generalized form, allowing for more than two categories of forecast outcomes.

Vuchelen and Gutierrez (2005a) proposed a direct test that looks specifically at forecast optimality and the informational content of multiple horizon forecasts compared to the last observation. Originally, this test looked at growth rates and was then applied to commodity and livestock forecasts in futures markets. For instance, Sanders, Garcia, and Manfredo (2008) applied this direct test to investigate the informational content of deferred futures prices of live cattle and hogs. They discovered that the distant-delivery contracts of hogs compared to live cattle are far more rational and provide valuable incremental information steadily throughout the twelve-month horizon they examined.

In futures markets, multiple contracts with increasingly distant expiration dates trade simultaneously. Since price discovery is one of the main goals of futures markets, we address the question of whether these distant-delivery futures contracts contain informational value for price discovery beyond that found in the more nearby contracts.

We contribute to the existing literature by testing for both forecast point accuracy and directional forecast ability and by applying the tests to both storable and non-storable commodities. We focus on live cattle and soybean futures contracts and employ both the direct test of forecast accuracy proposed by Vuchelen and Gutierrez (2005a) and the Henriksson and Merton (1981) directional ability test as modified by Pesaran and Timmermann (1994) to test for incremental information added beyond nearby-delivery futures prices.

Given that distant-delivery contracts generally trade at much lower volumes than the nearby contract, it is of interest to determine whether the distant-delivery contracts provide additional information into the (future) price discovery process.[1] We expect incremental information in all three nearby futures contracts (one, three, and five month out) for live cattle, because the biological lag associated with livestock means that the market cannot move immediately to equilibrium (since animals cannot go to slaughter until they are finished). Therefore, we expect to see price discovery value in distant contracts, since those futures prices represent a supply and demand equilibrium at a future date. However, for a storable commodity like soybeans, future supply and demand equilibria are linked to current market conditions through the ability to shift the timing of sales. Therefore, we do not expect to find information value in the distant-delivery futures prices for soybeans.

Literature Review

There is considerable related research in this area. The ability of futures markets to possess the quality of price discovery has been researched in many different commodity markets. Garbade and Silber (1983) found that prices changed in futures markets before cash markets, which they argued was evidence in favor of futures markets serving a role in price discovery, in addition to their role in risk management. Brorsen, Bailey, and Richardson (1984) found that cotton prices are discovered within futures markets. Their evidence was the strong positive relationship between cash prices and one-period lagged futures prices, proving that cash prices are quick to incorporate information

[1] We thank the editor for suggesting that the thin trading in distant contracts can be seen as the market's low opinion of the price discovery content of those distant contracts. Thus, believers of consensus wisdom should expect distant delivery futures contracts to have little additional information value.

provided by futures markets. Yang and Leatham (1999) took a different approach to researching price discovery by looking at the price relationships in three different futures markets for the same underlying commodity—wheat—rather than looking at the cash-futures price relationship. More specifically, they examined whether prices in the multiple futures markets are more likely to seek out equilibrium prices (futures-to-futures price discovery) than prices in the multiple cash markets (cash-to-cash price discovery). They found that the three U.S. wheat futures markets (Chicago Board of Trade, Kansas City Board of Trade, Minneapolis Grain Exchange) were driven by an equilibrium price in the long run, but wheat cash markets were not, implying that futures markets provided informed prices not found in cash markets.

Previous work has tested whether commodity prices behave systematically or in a random walk fashion. If futures prices are random walks, they should contain no valuable information about the future. Evidence in both directions exists in the literature. Leuthold (1972) found mixed results in cattle futures. Bessler and Covey (1991) found that while levels of live cattle futures prices follow a random walk, their first differences do not. Dorfman (1993) generally found both corn and soybean futures to be stationary. On the other hand, McKenzie and Holt (2002) showed that live cattle, hogs, corn, and soybean meal futures contain unit roots. Frank and Garcia (2009) analyzed the same commodities as in McKenzie and Holt and found corn, hogs, and soybean meal futures to be stationary after accounting for structural breaks.

As ably explained by Tomek (1997), Working's view (1949) of the information content of distant-delivery contracts was that for storable commodities, the distant-delivery contracts should have no additional information. Working believed that contracts were linked by storage price except in periods of backwardation brought on when inventories were so low that normal linkages broke down. In this view, we should only expect information content in distant-delivery contracts for non-storable commodities. Leuthold, Junkus, and Cordier (1989) back this view and make it clear that prices for two futures contracts of differing maturities are related to each other by the cost of carry between the two periods; specifically, the price of the more distant contract should be higher than the nearby contract by the amount of cost of carry. We test this theory by adjusting futures prices for different delivery month contracts of a storable commodity (soybeans) for the carry cost and then testing the adjusted series for information value in the distant-delivery contracts.

Non-storable commodities, such as livestock, do not have the same arbitrage-enforced linkage through storage, so future contracts for different delivery month have no economic theory to link them together (Gray and Rutledge, 1971). Instead, they should represent market expectations of equilibrium conditions at different future dates (Leuthold, Junkus, and Cordier, 1989). To some extent, this was empirically confirmed by Bessler and Covey (1991), who tested spot and various future cattle prices for cointegration. Bessler and Covey found only weak cointegration between the spot and nearby futures prices; any statistical linkage diminished as the time to delivery increased. Covey and Bessler (1995) found that the future price of live cattle contributes information to the discovery of daily cash price (average of daily high and low cash price of Texas-Oklahoma fed cattle). They found no informational contribution regarding future demand and supply conditions for St. Louis wheat and concluded that the informational disparity between an asset's intertemporal prices tends to increase with the disparity of storage costs or transaction costs. Naik and Leuthold (1988) found that cash price significantly and negatively affects futures prices four periods ahead for cattle, while it does not for hogs. They claimed that this is related to cattle having more flexibility than hogs on bringing them to market.

Recent tests for informational value in distant delivery contracts have obtained a variety of results. Outside of agricultural commodities, Alquist and Kilian (2010) tested crude oil futures contracts out to twelve months from expiration and find that only the three-month out contract forecasts better than a simple random walk (no-change) forecast model. Suenaga and Smith (2011) found low price correlation between crude oil, gasoline, and heating oil futures contracts maturing before and after the end of peak-demand season. They claimed that this is consistent with the theory of storage, which suggests that low inventory at the end of peak-demand season weakens the intertemporal price linkage. Sanders, Manfredo, and Boris (2008) used the Henriksson-Merton test to examine short-term supply forecasts of crude oil, natural gas, coal, and electricity, released by the U.S. Department of Energy's (DOE) Energy Information Administration (EIA). Results showed that the EIA accurately predicted year-over-year increases and decreases in supply for over 70% of the quarters, and again quarter-to-quarter changes in the rate of supply growth over 70% of the time. However, the EIA's forecasts only performed statistically better than the naïve no-change forecasts for coal. Using the Vuchelen and Gutierrez test, Sanders, Manfredo, and Boris (2009) analyzed the incremental information provided at the one- through four-quarter forecast horizons of the U.S. DOE's quarterly price forecasts for energy commodities. They concluded that the DOE's price forecasts for crude oil, gasoline, and diesel oil provide incremental information out to three-quarters ahead, and those for natural gas and electricity provide additional information out to four-quarters ahead. However, price forecasts for coal are found to provide incremental information only out to one-quarter ahead.[2]

In an agricultural commodity application, Sanders, Garcia, and Manfredo (2008) applied the Vuchelen and Gutierrez direct test to investigate the information content of deferred futures prices of live cattle and hogs. The information content of distant-delivery cattle futures diminished substantially beyond eight months, while hog contracts continued to contain information throughout the entire twelve-month horizon tested. The authors offered several explanations for this, one of which was the length of the beef production cycle. The Cattle on Feed (COF) report, the primary supply data released by the USDA, only provides good information six months ahead, since cattle are in feedlots for approximately six months. Hogs, on the other hand, have a shorter production cycle with the Hogs and Pigs Report (HPR) distributed quarterly. Thus, more timely information is available to hog producers.

The Vuchelen and Gutierrez direct test for incremental content that we apply here has also been applied to other agricultural areas, including USDA production forecasts. Sanders and Manfredo (2008) showed that only turkey and milk production forecasts exhibited rational additional information at each horizon, while four other commodities tested (beef, pork, broilers, and eggs) did not provide unique information along the multiple-horizon production forecasts.

Methodology of the Information Value Tests

We study the informational content of distant-delivery futures contracts by using two different tests that look at distinct measures of information content to determine whether the nearby and distant-delivery futures contracts add valuable information to the current spot market price. The first test is the Vuchelen and Gutierrez (2005a) direct test, where we use the last actual price as a benchmark to estimate incremental information between forecast periods. This test is based on measuring the accuracy of the futures prices as a forecast of spot prices at a specified future date. The second test is a directional analysis test developed by Henriksson and Merton (1981), which focuses on the ability to make correct predictions of the direction of price movement (up or down) from one period to the next.

Vuchelen and Gutierrez Direct Test

The test that Vuchelen and Gutierrez (2005a) developed uses a regression framework to measure whether futures prices improve one's ability to forecast spot prices at a future date. The test is based on decomposing the current futures price (F_t^{t+1}) into one part representing the current spot price and a second part representing the forecast change from that price $(F_t^{t+1} - S_t)$:

[2] Vuchelen and Gutierrez (2005b) apply their own test to OECD economic growth forecasts. They find them to have no informational content. We minimize the discussion of this application because it does not involve futures markets.

$$F_t^{t+1} = S_t + (F_t^{t+1} - S_t). \quad (1)$$

It is the second term on the right hand side of equation (1) that represents the potential information in the futures price. Equation (1) can be expanded to a two-step ahead forecast (F_t^{t+2}) by adding consecutive adjustments to the benchmark:

$$F_t^{t+2} = S_t + (F_t^{t+1} - S_t) + (F_t^{t+2} - F_t^{t+1}). \quad (2)$$

Again, the adjustments added to the last spot price observation are known as the information content of the forecast, which ideally provides valuable additional information beyond the last realization (Vuchelen and Gutierrez, 2005a). These fundamental equations are the basis of the Vuchelen and Gutierrez direct test.

The traditional equation used to evaluate forecasting efficiency of futures prices is:

$$S_{t+1} = \alpha + \beta F_t^{t+1} + u_{t+1}, \quad (3)$$

where u_{t+1} is the error term. By substituting equation (1) into equation (3), Vuchelen and Gutierrez (2005a) developed their direct test on the informational content of a one-step ahead forecast. We adapt their formula here for the fact that our data is nonstationary and, thus, we need to work in terms of rates of return in the spot and futures price series. Thus, the variables of interest for our study become $\ln(S_t/S_{t-1})$ for current cash return, $\ln(S_{t+1}/S_t)$ for one-month out cash return, $\ln(S_{t+3}/S_t)$ for three-month out cash return, $\ln(S_{t+5}/S_t)$ for five month out cash return, $[\ln(F_t^{t+1}/S_t) - \ln(S_t/S_{t-1})]$ for the value added with one-month out futures, $[\ln(F_t^{t+3}/F_t^{t+1}) - \ln(F_t^{t+1}/S_t)]$ for the value added with three-month out futures, and $[\ln(F_t^{t+5}/F_t^{t+3}) - \ln(F_t^{t+3}/F_t^{t+1})]$ for the value added with five-month out futures.

So, with data transformed into rates of return we arrive at an equation to test the information value of a one-step-ahead forecast of:

$$\ln\left(\frac{S_{t+1}}{S_t}\right) = \theta + \delta \ln\left(\frac{S_t}{S_{t-1}}\right) + \lambda\left[\ln\left(\frac{F_t^{t+1}}{S_t}\right) - \ln\left(\frac{S_t}{S_{t-1}}\right)\right] + u_{t+1}. \quad (4)$$

For two-step ahead (three-month out) forecasts, equation (4) becomes:

$$\begin{aligned}\ln\left(\frac{S_{t+3}}{S_t}\right) &= \theta + \delta \ln\left(\frac{S_t}{S_{t-1}}\right) + \lambda\left[\ln\left(\frac{F_t^{t+1}}{S_t}\right) - \ln\left(\frac{S_t}{S_{t-1}}\right)\right] + \\ &\omega\left[\ln\left(\frac{F_t^{t+3}}{F_t^{t+1}}\right) - \ln\left(\frac{F_t^{t+1}}{S_t}\right)\right] + u_{t+3}.\end{aligned} \quad (5)$$

Similarly, for three-step ahead (five-month out) forecasts we obtain:

$$\begin{aligned}\ln\left(\frac{S_{t+5}}{S_t}\right) &= \theta + \delta \ln\left(\frac{S_t}{S_{t-1}}\right) + \lambda\left[\ln\left(\frac{F_t^{t+1}}{S_t}\right) - \ln\left(\frac{S_t}{S_{t-1}}\right)\right] + \\ &\omega\left[\ln\left(\frac{F_t^{t+3}}{F_t^{t+1}}\right) - \ln\left(\frac{F_t^{t+1}}{S_t}\right)\right] + \eta\left[\ln\left(\frac{F_t^{t+5}}{F_t^{t+3}}\right) - \ln\left(\frac{F_t^{t+3}}{F_t^{t+1}}\right)\right] + u_{t+5}.\end{aligned} \quad (6)$$

The consecutive adjustments show the information content found in deferred futures contracts. In equation (4), the search for informational content focuses on the parameter λ. If $\lambda \neq 0$ then the nearby (one-month out) futures contract provides additional information beyond the current cash price. In equation (5), if $\omega \neq 0$ then the three-month out futures contract adds valuable information beyond the one-month out futures contract. Similarly, in equation (6), $\eta \neq 0$ implies the five-month out futures contract adds value to price discovery by adding incremental information beyond the one- and three-month out futures contracts.

Equation (4) can be estimated efficiently using ordinary least squares (OLS); however, due to overlapping forecast errors, equations (5) and (6) should not be estimated by OLS. OLS will still yield unbiased parameter estimates but the standard errors will be biased and inconsistent. Serial correlation arises when k, the forecast horizon, is farther than one period ahead. For multiperiod forecast horizons, actual values or spot prices are not yet known prior to the forecast, and therefore the corresponding forecast errors are not yet known either. This causes serially correlated error terms (Brown and Maital, 1981), which must be handled.

A common econometric technique to correct for overlapping data is to apply generalized least squares (GLS). The GLS method essentially eliminates the serial correlation in the error terms. This technique requires strict exogeneity between the regressors and the error terms. However, strict exogeneity clearly does not hold for multiperiod forecast horizons. Hansen (1979) and Hansen and Hodrick (1980) developed an alternative method to correct for inconsistent standard errors due to overlapping forecast horizons. Hansen and Hodrick begin by estimating:

(7) $$y_{t+k} = x_t\beta + u_{t,k},$$

where $u_{t,k}$ is the forecast error at time t for the k-step-ahead forecast, and y_{t+k} and x_t are the left and right hand side variables shown in equations (5) and (6). They prove that for sample size T and OLS estimator $\hat{\beta}_T$, $\sqrt{T}(\hat{\beta}_T - \beta)$ converges in distribution to a normally distributed random vector with mean zero and covariance matrix $\boldsymbol{\Theta}$,

(8) $$\boldsymbol{\Theta} = R_x(0)^{-1}\gamma R_x(0)^{-1},$$

(9) $$\gamma = \sum_{j=-k+1}^{k-1} R_u(j)R_u(j),$$

where

(10) $$R_u(j) = \mathrm{E}(u_{t,k}u_{t+j,k}),$$

and

(11) $$R_x(j) = \mathrm{E}(x_t'x_{t+j}).$$

Here we follow Hansen and Hodrick (1980) and obtain coefficient estimates via OLS but adjust our variance-covariance matrices of the error terms from the two-step (three-month out) and three-step ahead (five-month out) forecast equations. We first stack the T observations into a matrix, $\boldsymbol{X}_T = [X_1 \dots X_T]'$, and then form a $T \times T$ symmetric matrix, $\hat{\boldsymbol{\Omega}}_T$, as follows for our two step-ahead (three-month out) forecast:

(12) $$\hat{\boldsymbol{\Omega}}_T = \begin{bmatrix} \hat{R}_u^T(0) & \hat{R}_u^T(1) & 0 & 0 & 0 & \dots & 0 & 0 & 0 \\ \hat{R}_u^T(1) & \hat{R}_u^T(0) & \hat{R}_u^T(1) & 0 & 0 & \dots & 0 & 0 & 0 \\ 0 & \hat{R}_u^T(1) & \hat{R}_u^T(0) & \hat{R}_u^T(1) & 0 & \dots & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \dots & \hat{R}_u^T(1) & \hat{R}_u^T(0) & \hat{R}_u^T(1) \\ 0 & 0 & 0 & 0 & 0 & \dots & 0 & \hat{R}_u^T(1) & \hat{R}_u^T(0) \end{bmatrix},$$

where $\hat{R}_u^T(0) = \frac{1}{T}\sum_{t=1}^{T} \hat{u}_{t,2}^T\hat{u}_{t,2}^T$ and $\hat{R}_u^T(1) = \frac{1}{T}\sum_{t=2}^{T} \hat{u}_{t,2}^T\hat{u}_{t-1,2}^T$ and the $u_{t,k}$ are the forecast errors from equation (7). Similarly, for the three-step ahead (five-month out) forecasts the variance-covariance matrix estimator is:

(13) $$\hat{\boldsymbol{\Omega}}_T = \begin{bmatrix} \hat{R}_u^T(0) & \hat{R}_u^T(1) & \hat{R}_u^T(2) & 0 & 0 & \dots & 0 & 0 & 0 & 0 \\ \hat{R}_u^T(1) & \hat{R}_u^T(0) & \hat{R}_u^T(1) & \hat{R}_u^T(2) & 0 & \dots & 0 & 0 & 0 & 0 \\ \hat{R}_u^T(2) & \hat{R}_u^T(1) & \hat{R}_u^T(0) & \hat{R}_u^T(1) & \hat{R}_u^T(2) & \dots & 0 & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & 0 & \dots & \hat{R}_u^T(2) & \hat{R}_u^T(1) & \hat{R}_u^T(0) & \hat{R}_u^T(1) \\ 0 & 0 & 0 & 0 & 0 & \dots & 0 & \hat{R}_u^T(2) & \hat{R}_u^T(1) & \hat{R}_u^T(0) \end{bmatrix},$$

where $\hat{R}_u^T(0) = \frac{1}{T}\sum_{t=1}^{T}\hat{u}_{t,3}^T\hat{u}_{t,3}^T$, $\hat{R}_u^T(1) = \frac{1}{T}\sum_{t=2}^{T}\hat{u}_{t,3}^T\hat{u}_{t-1,3}^T$, and $\hat{R}_u^T(2) = \frac{1}{T}\sum_{t=3}^{T}\hat{u}_{t,3}^T\hat{u}_{t-2,3}^T$. Noting that:

$$T(\boldsymbol{X}_T'\boldsymbol{X}_T)^{-1} = \hat{R}_x^T(0)^{-1}, \tag{14}$$

and similar to equation (9):

$$T^{-1}(\boldsymbol{X}_T'\hat{\boldsymbol{\Omega}}_T\boldsymbol{X}_T) = \sum_{j=-k+1}^{k-1}\hat{R}_u^T(j)\hat{R}_x^T(j), \tag{15}$$

Hansen and Hodrick conclude that:

$$\hat{\boldsymbol{\Theta}}_T = T(\boldsymbol{X}_T'\boldsymbol{X}_T)^{-1}\boldsymbol{X}_T'\hat{\boldsymbol{\Omega}}_T\boldsymbol{X}_T(\boldsymbol{X}_T'\boldsymbol{X}_T)^{-1}, \tag{16}$$

which is a consistent estimator for the asymptotic covariance matrix and what we employ to operationalize the Vuchelen and Gutierrez test.

Henriksson and Merton Test

The Henriksson and Merton test analyzes the ability to predict the direction of change in the variable being studied (Pesaran and Timmermann, 1992). In our research we are looking at the directional accuracy of nearby and deferred futures prices. The observed forecast accuracy of futures prices in predicting the direction of movement in the spot market can be transformed into probabilities, with P_{ij} being the probability of the event that the realized return movement falls in category i and the predicted return movement falls in category j. When the probabilities of m categories are represented in a contingency table, it takes on the form of a matrix, which we call $\boldsymbol{P}$:

$$\boldsymbol{P} = \begin{bmatrix} P_{11} & P_{12} & \dots & P_{1m} \\ P_{21} & P_{22} & \dots & P_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ P_{m1} & P_{m2} & \dots & P_{mm} \end{bmatrix}. \tag{17}$$

Each row of $\boldsymbol{P}$ measures the probability of correct and various incorrect forecasts of the times when actual price movement fell into category i. The main diagonal of $\boldsymbol{P}$ holds the probabilities of correct forecasts. We have categories for price movements of up, down, and no change, so our $\boldsymbol{P}$ matrix is 3×3. Using this contingency table Pesaran and Timmermann (1992) derive a non-parametric procedure for testing the null hypothesis H_0^{**} of no market timing (no incremental information in our study):

$$H_0^{**}: \qquad \sum_{i=1}^{n}(\hat{P}_{ii} - \hat{P}_{i0}\hat{P}_{0i}) = 0. \tag{18}$$

It is a standard result for the maximum likelihood estimator of $P_{ij}(\hat{P}_{ij})$ that:

$$\sqrt{n}(\hat{\boldsymbol{P}} - \boldsymbol{P}_0) \sim N(0, \boldsymbol{\Psi}_0 - \boldsymbol{P}_0\boldsymbol{P}_0'), \tag{19}$$

where $\boldsymbol{P}_0$ is the $m^2 \times 1$ column vector equal to vec($\boldsymbol{P}$), $\hat{\boldsymbol{P}}$ is the estimated value of vec($\boldsymbol{P}$), and $\boldsymbol{\Psi}_0$ is a $m^2 \times m^2$ diagonal matrix which has $\boldsymbol{P}_0$ as its diagonal elements. The test of H_0^{**} is based on the statistic:

$$S_n = \sum_{i=1}^{n}(\hat{P}_{ii} - \hat{P}_{i0}\hat{P}_{0i}), \tag{20}$$

where $\hat{P}_{ij} = n_{ij}/n$, $\hat{P}_{i0} = n_{i0}/n$, and $\hat{P}_{0i} = n_{0i}/n$ are the estimates of the forecast outcome probabilities, with n_{ij} representing the number of observations where the realized price movement falls in category i and the predicted price movement falls in category j, n_{i0} representing the number of observations where the realized price movement falls in category i and the predicted price movement varies, and n_{0i} representing the number of observations where the realized price movement varies and the predicted price movement falls in category i. Under H_0^{**}:

$$\sqrt{n}S_n \sim N(0, \boldsymbol{V}_S), \tag{21}$$

where

$$\boldsymbol{V}_S = \left(\frac{\partial f(\boldsymbol{P}_0)}{\partial \boldsymbol{P}}\right)' (\boldsymbol{\Psi} - \boldsymbol{P}_0\boldsymbol{P}_0') \left(\frac{\partial f(\boldsymbol{P}_0)}{\partial \boldsymbol{P}}\right), \tag{22}$$

and

$$\begin{aligned} \frac{\partial f(\boldsymbol{P})}{\partial P_{ij}} &= 1 - P_{0i} - P_{i0}, \quad \text{for} \quad i = j; \\ &\quad -P_{j0} - P_{0i}, \quad \text{for} \quad i \neq j. \end{aligned} \tag{23}$$

Thus, the test statistic can be written as:

$$Z_n = \sqrt{n}\boldsymbol{V}_S^{-1/2} S_n \sim N(0,1), \tag{24}$$

which is a standard normal Z-statistic. In fact, the test as described is the Fisher exact test for this hypothesis. Pesaran and Timmermann (1994) recommend a one-sided test since only positive values of the test statistic provide evidence of incremental information. However, one can define significant, negative test statistics as showing information value since a reliably incorrect forecast is also valuable.

Data

We focus our tests on live cattle and soybean futures contracts traded at the Chicago Mercantile Exchange (CME) Group. Live cattle futures have a contract size of 40,000 pounds priced in cents per pound. The deliverable product must be 55% Choice, 45% Select and Yield Grade 3 live steers. Delivery months are February, April, June, August, October, and December. Contracts expire on the last business day of the delivery month. Live cattle contracts are subject to a daily price limit of three cents per pound above or below the previous day's settlement price. For live cattle cash prices, we follow Bessler and Covey (1991) and use the daily closing prices of the Texas-Oklahoma average from the USDA.[3]

The standard soybean contract size is 5,000 bushels of No. 2 yellow soybeans at par, No.1 yellow soybeans at a six cent premium, and No.3 yellow soybeans at a six cent discount. Contracts are priced in cents per bushel. Delivery months are January, March, May, July, August, September, and November. Contracts expire on the last business day prior to the fifteenth calendar day of each delivery month. Daily price limits are 70 cents per bushel, which is expandable when the market

[3] An alternative cash price series is the five-area weighted average, which includes Texas/Oklahoma/New Mexico, Kansas, Nebraska, Colorado, and Iowa/Minnesota feedlots. However, we expect the basis effect due to this difference in data to be minor. Along those lines, any basis between this cash price and that at an official delivery location will not affect our results as long as the basis is constant over our sample period (it will change the intercept in the model, but not the test results). The CRB provides this cash price with their futures price data, suggesting that they feel it is a good choice for measuring the spot price.

Table 1: Descriptive Statistics

		Current Cash	1-Month Out Cash	3-Month Out Cash	5-Month Out Cash	1-Month Out Futures	3-Month Out Futures	5-Month Out Futures
Live Cattle	Mean	75.56	75.35	75.36	75.49	75.84	75.74	75.45
(Cents/lb.)	Median	74.00	74.00	74.00	74.00	74.63	73.65	72.30
	Minimum	57.00	57.00	57.00	57.00	58.88	59.93	61.30
	Maximum	100.05	101.19	101.19	101.19	99.25	106.30	109.03
	Std. Dev.	10.24	10.53	10.58	10.55	10.25	10.56	10.62
Soybeans	Mean	631.64	640.32	645.14	647.04	645.73	647.17	647.21
(Cents/bushel)	Median	581.00	578.00	574.00	576.00	590.50	596.75	606.00
	Minimum	406.50	401.50	426.00	426.00	429.25	438.75	433.50
	Maximum	1,517.50	1,552.50	1,552.50	1,552.50	1,560.00	1,540.00	1,531.00
	Std. Dev.	186.89	192.15	194.62	195.68	192.65	191.49	186.65

Notes: Descriptive statistics are generated with raw price series data from January 19, 1990 - September 30, 2008 for live cattle and February 21, 1990 - October 14, 2008 for soybeans.

closes at limit bid. For cash price series, we use the closing price of Central Illinois No. 1 yellow soybeans acquired from the USDA.[4]

We record the daily closing cash prices one month prior the nearby contract's expiration date to represent current cash price. Then we use the daily closing prices of the first three nearby contracts on the same day to represent one-, three-, and five-month ahead forecasts. For live cattle, even-month futures contracts are used, resulting in a sample period of January 19, 1990, to September 30, 2008. The first price observations for live cattle, for instance, include cash price and settlement prices for February, April, and June 1990 contracts observed on January 19, 1990. Because we only use odd delivery months for soybeans (skipping the August contract to make the delivery months fall on every other month), our sample period for this commodity starts on February 21, 1990, and extends to October 14, 2008, recording prices every other month. For example, the first data point in our sample includes cash price and settlement prices for March, May, and July 1990 soybean contracts on February 21, 1990. The total number of observations is 113 for each commodity. Table 1 includes descriptive statistics.

Previous research with distant-delivery futures contracts has avoided storable commodities, such as soybeans, because storage cost and opportunity cost must be considered to make a fair comparison between nearby and distant prices. Sanders, Garcia, and Manfredo (2008) touch on this issue, stating that the Vuchelen and Gutierrez direct test is less straightforward due to the explicit storage relationship between futures contracts within a crop year. Accordingly, we adjust our soybean price series for opportunity and storage costs. This is accomplished by computing an adjustment factor, similar to the one presented in Zulauf, Zhou, and Roberts (2006). We multiply current cash price by a daily interest rate and by the proportion of the year between that day and either the one-, three-, or five-month out futures contract expiration date to calculate the opportunity cost. Next, we add the one-time fixed storage cost and the variable storage cost (if necessary). Fixed cost covers storage for any length of time from harvest through December. The additional variable cost is a pro-rated daily charge starting from January 1st until the futures contract expiration. The fixed storage cost applies for the dates between September and December 31st (after harvest) and variable storage cost applies for the dates between January and August (before the next harvest). Storage cost rates were obtained from Darrel Good (2011) and are shown in table 2. Interest rates are the three-month U.S. Treasury

[4] Since we are using No.1 yellow soybeans, we are introducing a constant basis increase of six cents. As shown in the discussion of the information value tests, this constant basis will not affect the results of our tests for information value. An argument similar to that in footnote 3 also applies again for our use of a cash price at a non-delivery location. Again, this is the cash price provided by the CRB with their futures price data.

Table 2: Soybean Storage Costs

Period	Fixed Cost (per bushel)	Monthly Variable Cost (per bushel)
1989 - 2006	$0.13	$0.020
2007	$0.16	$0.026
2008 - 2010	$0.18	$0.030

Notes: Data obtained from Good (February 23, 2011). Fixed cost expressed as a one-time fee applied for the dates between September and December 31st (after harvest). Variable cost is a pro-rated daily charge starting after January 1st and ending August 31st (before the next harvest).

Table 3: Results for Vuchelen and Gutierrez Direct Test

	Live Cattle			Soybeans		
	1-Month Out	3-Month Out	5-Month Out	1-Month Out	3-Month Out	5-Month Out
Intercept (θ)	−0.01	−0.00	0.00	−0.00	0.00	−0.00
	(−1.54)	(−0.02)	(0.02)	(−0.35)	(0.01)	(−0.01)
Cash (δ)	0.82	0.96	1.26	0.92	2.41	4.46
	(4.33)**	(0.30)	(0.23)	(3.88)**	(0.41)	(0.40)
1 Month (λ)	0.59	0.91	1.34	0.74	2.35	4.35
	(3.68)**	(0.33)	(0.28)	(3.17)**	(0.41)	(0.40)
3 Months (ω)		1.04	1.19		1.64	3.07
		(0.46)	(0.37)		(0.43)	(0.38)
5 Months (μ)			0.82			2.06
			(0.30)			(0.35)

Notes: We report coefficients and (t-values). Asterisks (**) represent significance at the 5% level.

Table 4: Results for Henriksson and Merton Test

Z-statistic (p-value)	1-Month Out	3-Month Out	5-Month Out
Live Cattle	3.43**	2.38**	0.63
	(0.00)	(0.01)	(0.26)
Soybeans	2.96**	0.86	1.75**
	(0.00)	(0.19)	(0.04)

Notes: *Z*-statistics and their p-values (in parentheses) are shown. Asterisks (**) represent significance at the 5% level.

Bill rates obtained from the St. Louis Federal Reserve Bank. After adjustment for opportunity and storage costs, the futures returns can be compared to one-, three-, and five-month out cash returns.

Data Preparation for the Vuchelen and Gutierrez Direct Test

Augmented Dickey-Fuller (ADF) tests with twelve lags show the presence of a unit root in both the cattle price series and the soybean price series after adjustment for opportunity and storage costs at the $p = 0.05$ level (that is, we cannot reject the null of a unit root). Thus, we convert our price series to rates of return. ADF test results for the rates of return series allow us to reject the null hypothesis of a unit root. Therefore, we can properly use the series in rate of return form in our regression equations.

Data Preparation for Henriksson and Merton Test

To perform the Henriksson and Merton (1981) test as modified by Pesaran and Timmermann (1992), we use three categories: movement up, movement down, and no change. The probabilities of the nine possible events can be arranged into a matrix as in equation (17), where we use the ordering 1 = up, 2 = down, and 3 = no change.

We compute the direction of one-month ahead forecast movement by comparing the price of one-month out futures contracts to cash price a month prior to expiration, and the direction of one-month actual movement by comparing cash price on the expiration day to the cash price a month before. For three-month out forecast movements, we compare the price of the three-month out contract to the price of the one-month out contract, and for the direction of three-month out actual movement, we compare the three-month out cash price to the one-month out cash price. Similarly, we compare the five-month out futures price to the three-month out futures price, and the five-month out cash price to the three-month out cash price.

Results

Vuchelen and Gutierrez Direct Test

Table 3 shows the regression results for the Vuchelen and Gutierrez direct test for both live cattle and soybeans.[5] The test for information in the one-month out futures contract for live cattle reported a significant t-value of 3.68, strong evidence that one-month out futures contracts provide valuable information. This is to be expected, since this is the nearby contract and the highest volume of trading is done within this contract. The one-month out soybean futures contract shows a similar result with a significant t-value of 3.17. The results for the three-month out futures contracts for both live cattle and soybeans were statistically insignificant, implying that there is no valuable additional information beyond the one-month out futures contracts. The same proved to be true for the five-month out futures contracts for both commodities, both suggesting no additional information in the five-month out futures contracts beyond the three-month out contracts. The live cattle results are somewhat surprising since the non-storable nature of the commodity made us expect distant-delivery futures contracts to provide valuable information about future expected equilibrium market prices which would not be expected to be contained in the nearby contract (Leuthold, Junkus, and Cordier, 1989). An alternative explanation for the lack of information value in the distant-delivery cattle contracts is that while the non-storable nature of the commodity weakens linkages over time, the long production cycle of cattle also means that market participants know approximately what supply will be in future months and can use that information to smooth out prices over time. The cattle results here somewhat contradict the findings in Sanders, Garcia, and Manfredo (2008) who found additional information in live cattle futures prices out past the five months that we examine. Absent a price discovery role for distant futures contracts, their existence could still be explained by a preference for single, longer horizon hedging instruments over using a sequence of hedging on the nearby contract (rollover hedging) to manage price risk over periods longer than two months.

Henriksson and Merton Test

The probability matrices for the one-month, three-month, and five-month out forecasts for live cattle are shown below, denoted as $\boldsymbol{P1}_{LC}$, $\boldsymbol{P3}_{LC}$, and $\boldsymbol{P5}_{LC}$, respectively. Specifically we compute:

[5] The interpretation of the coefficients in the Vuchelen and Gutierrez test is not fully clear. At the simplest level, a coefficient value that differs from zero signals information value, but that does not say anything about how to interpret the magnitude of the estimated coefficient. The best insight we can offer is that the coefficient is similar to a (scaled) signal-to-noise ratio. If it is zero, there is only noise and, hence, no information. As the coefficient on the most distant contract approaches one, the contract is signaling very accurate information on the upcoming change in the spot price. A coefficient over one is an overenthusiastic forecast of directional change, but still contains useful information.

$$\boldsymbol{P1}_{LC} = \begin{bmatrix} 0.345 & 0.142 & 0 \\ 0.168 & 0.266 & 0 \\ 0.053 & 0.027 & 0 \end{bmatrix}, \quad \boldsymbol{P3}_{LC} = \begin{bmatrix} 0.337 & 0.195 & 0 \\ 0.186 & 0.266 & 0 \\ 0.009 & 0.009 & 0 \end{bmatrix},$$

$$\boldsymbol{P5}_{LC} = \begin{bmatrix} 0.283 & 0.239 & 0.009 \\ 0.186 & 0.230 & 0 \\ 0.018 & 0.009 & 0 \end{bmatrix}. \tag{25}$$

The diagonals of the matrices represent the probabilities of correct forecasts for each category of price movement. The sum of the diagonal of $\boldsymbol{P1}_{LC}$ shows a 61.1% probability of a correct forecast for the one-month ahead live cattle futures, while $\boldsymbol{P3}_{LC}$ shows a 60.3% probability of a correct forecast for the three-month ahead futures, and $\boldsymbol{P5}_{LC}$ shows a 51.3% probability of a correct forecast for the five-month ahead futures. This gives us some indication of the likely test results using the formal statistic derived by Pesaran and Timmermann (1994).

The probability matrices for soybeans can be reported the same way:

$$\boldsymbol{P1}_{S} = \begin{bmatrix} 0.575 & 0.009 & 0 \\ 0.336 & 0.080 & 0 \\ 0 & 0 & 0 \end{bmatrix}, \quad \boldsymbol{P3}_{S} = \begin{bmatrix} 0.354 & 0.186 & 0 \\ 0.266 & 0.195 & 0 \\ 0 & 0 & 0 \end{bmatrix},$$

$$\boldsymbol{P5}_{S} = \begin{bmatrix} 0.398 & 0.150 & 0 \\ 0.257 & 0.195 & 0 \\ 0 & 0 & 0 \end{bmatrix}. \tag{26}$$

The sum of the diagonal of $\boldsymbol{P1}_{S}$ yields a 65.5% probability of a correct forecast, $\boldsymbol{P3}_{S}$ shows a 54.9% probability of a correct forecast, and $\boldsymbol{P5}_{S}$ implies a 59.3% probability of a correct forecast.

We report the Z-statistics from the Henriksson-Merton tests in table 4. Both live cattle and soybeans report statistically significant Z-statistics of 3.43 and 2.96 for one-month out forecasts. These results, which match the results from the Vuchelen-Gutierrez test, show valuable information being added to the spot price by the futures contracts one-month out. Results are different, however, with the three-month out forecasts between live cattle and soybeans. The test on three-month out futures contracts for live cattle has a Z-statistic of 2.38 which shows additional information added to the one-month out contracts, but the test on three-month out futures contracts for soybeans is statistically insignificant, suggesting no valuable informational content added beyond the one-month horizon. The five-month out futures contracts for soybeans provided an interesting result. With a statistically significant Z-statistic of 1.75, we see valuable information beyond the three-month out futures contracts. This result, as well as the three-month out futures contracts for live cattle, differs from the results found with the Vuchelen-Gutierrez test. The five-month out live cattle futures contracts displayed no additional information value.

Discussion

Based on these results, we conclude that the one-month out forecasts for both live cattle and soybeans can predict price movements in the spot market. We can further conclude that the three-month out soybean and five-month out cattle contracts do not contain valuable information for price discovery. However, our findings for the three-month out cattle and five-month out soybeans contracts are conflicting. The Henriksson-Merton test finds information in these two distant-delivery contracts while the Vuchelen-Gutierrez test does not.

The conflict can be explained by remembering that the tests are not measuring information in the same dimension. The Henriksson-Merton test is looking at the ability to predict the direction of price

Table 5: Results for Soybeans without Backwardation

(a) Vuchelen and Gutierrez Test	**1-Month Out**	**3-Month Out**	**5-Month Out**
Intercept (θ)	−0.01	−0.02	−0.03
	(−0.47)	(−0.10)	(−0.11)
Cash (δ)	1.02	1.42	2.91
	(3.03)**	(0.09)	(0.11)
1 Month (λ)	0.89	1.33	2.73
	(2.81)**	(0.09)	(0.11)
3 Months (ω)		−0.59	−0.14
		(−0.03)	(−0.00)
5 Months (μ)			2.11
			(0.13)

(b) Henriksson and Merton Test	**1-Month Out**	**3-Month Out**	**5-Month Out**
Soybeans	2.14**	−0.41	1.18
	(0.02)	(0.34)	(0.12)

Notes: Panel (a) reports coefficients and (t-values). Panel (b) shows Z-statistics and their p-values (in parentheses). Asterisks (**) represent significance at the 5% level.

revisions, while the Vuchelen-Gutierrez test is searching for the ability to make an accurate point forecast. If the forecast is a downward price movement of one cent, and the actual price movement is upward one cent, that would be an incorrect forecast for the Henriksson and Merton test, but is likely to be seen as very valuable in the Vuchelen and Gutierrez sense. The opposite could happen as well. The futures price could forecast an increase of forty cents, but the actual spot price only increases two cents. This forecast will show information within our directional price movement test (Henriksson and Merton test), but likely will show little incremental information within our price-point estimate test (Vuchelen and Gutierrez test) because this forecast was very inaccurate in a mean-squared error sense. Because the test philosophies vary, the results can differ.

To investigate whether the results found for soybeans are influenced by the occasional backwardation in the market, we recomputed all tests with any periods where the soybean market was in backwardation deleted from the sample. The results (in table 5) from the remaining seventy-eight observations, show similar results for the Vuchelen-Gutierrez test but slight differences in the Henriksson-Merton results. When the periods of backwardation are eliminated, the results of both tests agree on finding information value only for the one-month out contract. If we use intercept and slope dummies to test periods of both backwardation and normal carry, we find no significant information in any of the contracts for the periods when the market is backwardated and we replicate the previous results for the normal carry observations (results available from the authors). It is also worth noting that the information value in distant delivery futures contracts found before, perhaps surprising given the storable nature of the commodity, may be influenced by the opposite season production from South America, which is of quite significant size. The South American industry uses American futures markets for their hedging because their local markets are too thin to handle their current scale of production.

Overall, these findings seem generally to confirm Working's ideas for storable commodities and distant-delivery contracts; that is, little information exists outside the nearby contract. However, we find less information than expected in the distant-delivery contracts for our non-storable commodity, live cattle, where there should not be enough managed-storage arbitrage to link up the contracts with differing delivery dates. It could be that the four-month gap between one-month and five-month out contracts is not long enough to fully de-link the markets and find the additional information we would expect. Unfortunately, increasing the gap means working with data on contracts traded very thinly, but is worth considering for future research.

Conclusions and Implications

Hedgers, speculators, farmers, processors, and consumers all rely on futures markets to hedge risk or make financial decisions based on future prices. However, if distant-delivery futures markets give no insight into future prices by simply making random adjustments to nearby futures prices and do not add valuable information leading to price discovery, then reliance on (distant-delivery) futures contracts is ill-advised. To test the informational value of deferred futures contracts in price discovery, we applied Vuchelen-Gutierrez and Henriksson-Merton tests to live cattle and soybeans futures markets. Nearby contracts were seen by both tests to contain value toward price discovery. Since the first nearby contract is traded more heavily than distant-delivery contracts, this is to be expected. The three- and five-month out futures contracts had mixed results from both tests. The Vuchelen-Gutierrez test shows no valuable information beyond the one-month out futures contracts for both commodities while the Henriksson-Merton test shows valuable information in the three-month out futures contracts for live cattle and in the five-month out futures contracts for soybeans. However, the finding of information in the five-month out soybeans futures contract disappears when our sample is modified to account for periods of backwardation. Overall, we believe these results make sense for the soybeans futures but are surprising enough to encourage further study of deferred cattle futures contracts.

These results make it evident that reliance on distant-delivery soybean and live cattle futures contracts can be misleading. If a grain farmer is deciding what to plant based on deferred futures contract prices, the farmer may be misled if these prices are simply random adjustments to spot prices and hold no value toward price discovery. The results in this paper do not clearly repudiate the role of distant-delivery futures contracts as longer horizon point forecasts, but they do not confirm their value in that role either.

However, even if distant-delivery futures contracts are not helpful for price discovery they can still serve a useful purpose in their role as longer-run hedging instruments to reduce price risk. Agents wishing to hedge against planned future sales or purchases of a commodity may not want to continually roll over hedges built with only nearby contracts, so distant-delivery contracts have a convenience factor for longer-term hedgers and offer complete certainty about locked-in price. Perhaps they are a type of niche product used to hedge price risk by those market agents with the need to offset risk over those time horizons.

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