Information Content in Deferred Futures Prices: Live Cattle and Hogs

by

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Practitioner's Abstract

The marginal forecast information contained in deferred futures prices is evaluated using the direct test of Vuchelen and Gutierrez. In particular, the informational role of deferred futures contracts in live cattle and hogs is assessed from the two- to twelve-month horizons. The results indicate that unique information is contained in live cattle futures prices out through the ten-month horizon, while hog futures prices add incremental information at all tested horizons. Practitioners using futures-based forecasting methods are well-served by deferred hog futures prices; however, live cattle futures listed beyond the 10 month horizon are not adding incremental information.

Key Words: forecast information, forecast evaluation, livestock futures

Introduction

Futures prices play a key role in production and consumption decisions in agriculture (Gardner; Hurt and Garcia), and they are often touted as useful and low-cost price forecasts for agribusinesses making economic decisions (Kastens, Jones, and Schroeder). Given the reliance on futures prices as forecasts, it is critical to understand their forecasting performance. Indeed, optimal and efficient forecasts can enhance social welfare by improving economic decisions (Stein; Kenyon, Jones, and McGuirk). Forecast users, depending on their information needs, are likely to desire futures price forecasts at varying horizons. For instance, agribusinesses making strategic production decisions are likely to need longer-term price forecasts commensurate with their decision-making horizon. Because of this, it is especially important to understand the forecasting performance of deferred futures contracts.

A large collection of research exists on futures market efficiency and forecasting (Tomek; Garcia and Leuthold). A majority of the research focuses on semi-strong form efficiency by comparing futures forecast accuracy to that of an alternative forecasting model such as time series and econometric models (Leuthold, et al., 1989), commercial services (Just and Rausser), and forecast produced by other market experts such as extension economists (Irwin, Gerlow, and Liu; Sanders and Manfredo). For agricultural commodities, the overall results of these studies are mixed depending on the markets examined and alternative forecasting methods (Garcia, Hudson, and Waller). Generally speaking, futures pricing efficiency has been rejected most often using *ex post* forecasts generated by the researchers' own models, and in the livestock markets (Irwin, Gerlow, and Liu). In particular, Irwin, Gerlow, and Liu indicate that there is evidence of forecast inefficiency in the livestock markets, especially at longer forecast horizons (Leuthold and Hartman;

Leuthold, et al., 1989). Likewise, Sanders and Manfredo document the potential for inefficiency in deferred fluid milk futures when testing forecast efficiency in an encompassing framework.

While prior research suggests that nearby futures provide largely efficient forecasts, less conclusive evidence exists for the forecasting efficiency of deferred futures prices, especially in the livestock markets. Therefore, in this research we incorporate a direct test for forecast information content proposed by Vuchelen and Gutierrez to specifically test the information content of deferred futures prices for two non-storable commodities - live cattle and hogs. Hence, in this research we take the nearby futures efficiency as a maintained hypothesis, and test for any additional information contained in deferred futures prices. For example, if the April futures price is at $75.00 and the June futures are priced at $77.00, are the June futures adding any additional information relative to the April price; or, is the June price simply reflecting a random adjustment to the information contained in the April futures price? The results provide a unique perspective on the information provided by deferred futures prices for these non-storable commodities. For instance, if futures prices are only adding information for the first six months of listed contracts, then there may not be any justification for using more deferred futures in decision-making. Likewise, the applied methodology will isolate horizons at which there appears to be little marginal information; thereby, it may indicate reasonable limits and expectations for futures-based forecast horizons. Alternatively, the results may suggest a relative scarcity of public information available to the marketplace for forming longer-term expectations.

It is important to note that this research is not testing for futures market efficiency *per se,* since the futures forecasts are not compared either directly or indirectly to alternative forecasting models. Instead, we assume that the nearby futures market provides the best available forecast, and then seek to determine the maximum horizon at which the marketplace is incorporating unique information into the market price. Therefore, agribusinesses that utilize futures prices as forecasts will better understand the effective horizon of their futures-based forecasts. If futures forecasts derived from deferred contracts are found to contain no unique information relative to forecasts derived from more nearby contracts, it may call into question the quality of public information often used by futures market participants (e.g., *Hogs and Pigs* report, *Cattle on Feed* report, and other public information). Essentially, the presented methods provide a unique way of analyzing futures market forecasts. Given futures based forecasts are generally believed to be the best forecasts available, how are they performing at alternative horizons?

A Direct Test for Information

Traditionally, forecast efficiency has been tested with the following regression,

(1) $$A_{t+1} = \alpha + \beta F_t^{t+1} + u_{t+1}.$$

Where, A_{t+1} is the realized value at time t+1, F_t^{t+1} is the forecast for time t+1 made at time t, and u_{t+1} is the error term. The traditional test of forecast rationality is under the joint null hypothesis of a zero intercept (α=0) and unitary slope coefficient (β=1). Moreover, the efficient forecast is characterized by an i.i.d. error term with no serial correlation in u_{t+1}.

Holden and Peel have shown that the traditional joint null hypothesis is a sufficient, but not necessary, condition for rationality. Therefore, a rejection of the null hypothesis in (1) does not lead to clear alternative statements about forecast properties. Given this, Granger and Newbold suggest researchers focus strictly on the error terms and a number of studies have employed these methods (see Pons). However, while this approach is informative in regards to forecast quality, it says little about information content.

Vuchelen and Gutierrez develop a direct test for information content by writing forecasts as simply the sum of consecutive adjustments to the most recent observation. The one-period ahead forecast can be decomposed into the following components,

(2) $F_t^{t+1} = A_t + (F_t^{t+1} - A_t)$, and for the two-step ahead forecast,

(3) $F_t^{t+2} = A_t + (F_t^{t+1} - A_t) + (F_t^{t+2} - F_t^{t+1})$.

From (2), it is clear that the one-step ahead forecast can be expressed as a simple adjustment to the current level. That is, the one-step ahead forecast, F_t^{t+1}, is equal to the current level, A_t, plus the expected change or adjustment from the current level, (F_t^{t+1}-A_t). Likewise, in (3), the two-step ahead forecast is equal to the current level, A_t, plus the forecasted change from the current level plus the forecasted adjustment in the following period.

Vuchelen and Gutierrez develop the direct test by substituting the decomposition in (2) into (1) to get the one-step ahead test,

(4) $A_{t+1} = \theta + \kappa A_t + \lambda(F_t^{t+1} - A_t) + u_t$.

In (4) we can see that A_{t+1} is equal to previous period's value, A_t, plus the forecasted change in the value, (F_t^{t+1} -A_t). This representation provides a wealth of information about the forecast's quality and information content. An unbiased and efficient forecast is characterized by θ=0 and λ=κ=1, in which case (4) simplifies to (1). However, a forecast that contains information only requires that $\lambda \neq 0$. So, the Vuchelen and Gutierrez test provides a more revealing examination of forecast performance in the sense that it allows for the testing of both optimal properties and information content simultaneously. The test for information content, however, is perhaps more interesting in the case of multiple step-ahead forecasts.

The test equation for two-step ahead forecasts is developed by substituting equation (3) into (1),

(5a) $$A_{t+2} = \gamma + \delta A_t + \eta(F_t^{t+1} - A_t) + \varepsilon(F_t^{t+2} - F_t^{t+1}) + u_{t+1}.$$

In (5a), an unbiased forecast is tested under the null that $\gamma=0$, and $\delta=\eta=\varepsilon=1$. Again, under the null hypothesis, equation (5a) simplifies to the two-step ahead version of (1). Note, however, equation (5a) tells us the amount of information that F_t^{t+2} provides relative to the most recent observation, (A_t) and the one-period ahead forecast F_t^{t+1}. That is, if $\varepsilon=0$, then the two-step ahead forecast is not providing any incremental information over the one-step ahead forecast. This is perhaps more easily seen by a further simplification of (5a), by again substituting (2) into (5a) and simplifying,

(5b) $$A_{t+2} = \gamma + \phi F_t^{t+1} + \mu(F_t^{t+2} - F_t^{t+1}) + u_{t+2}.$$

In (5b) the null hypothesis that the two-step ahead forecast, F_t^{t+2}, adds no incremental value to the one-step ahead forecast, F_t^{t+1}, is tested under $\mu=0$. Through repeated substitution, it is easy to show that the direct test for k-step ahead forecasts can be expressed as follows,

(5c) $$A_{t+k} = \beta_1 + \beta_2 F_t^{t+k-1} + \beta_3(F_t^{t+k} - F_t^{t+k-1}) + u_{t+k}\ .$$

In equation (5c), the null hypothesis that the k-step ahead forecast, F_t^{t+k}, adds no incremental value to the k-1 step ahead forecast, F_t^{t+k-1}, is tested under $\beta_3=0$. A more stringent rationality test would require that $\beta_3=\beta_2=1$, $\beta_1=0$.

As discussed by Vuchelen and Gutierrez, equation (4) can be estimated using standard OLS procedures. However, versions of equation (5c) with $k>1$ is characterized by overlapping forecast horizons, which will result in correlated forecast errors and subsequent biased and inconsistent standard errors. To correct this problem, we follow Brown and Maital and use the OLS coefficient estimates, but correct the variance-covariance matrix using the methods proposed by Hansen and used by Hansen and Hodrick.

Data

The direct test developed above is applied to two traditional futures markets for non- or semi-storable commodities: live cattle and live (lean) hogs.[1] These markets are chosen because they represent the most actively traded non-storable commodities. Moreover, there is a long history for both futures contracts allowing the compilation of a relatively long time series. For both live cattle and hog futures, deferred futures contracts begin

[1] The contract specification on hog futures was altered from live hogs (physical delivery) to lean hogs (cash settlement) with the February 1997 contract. In this paper, to avoid confusion, we refer to it as simple the hog futures market in reference to the time period covered by both contract specifications.

trading approximately one year prior to expiration, which allows for the examination of forecasts with horizons up to twelve-months ahead.[2]

Following the convention established by Tomek and Gray (see also Kenyon, Jones, and McGuirk; Zulauf, Irwin, Ropp, and Sberna), we assume that deferred futures prices are trying to forecast the delivery time futures price. For instance, at the end of October, the December futures quote is considered a two-month ahead forecast for the December futures price that will exist on the first notice day for delivery (the last trading day of November). More explicitly, the futures price for the December contract at the end of October is defined as f_t^{t+2} and the first notice day price for the December contract is a_{t+2} or the actual realized price two months hence.

Following this format, futures prices are collected on the last trading day of each month beginning 12 months prior the first notice day. For example, the December futures contract's price in November of the prior year represents a twelve-month ahead forecast. Both live cattle futures and live hog futures have a contract cycle that includes the even months of February, April, June, August, October, and December. So, there are six realized or actual prices per year that are being forecast, which generates evenly spaced time series observations at 60 day intervals or steps. The data are collected for the February 1975 contract through the February 2007 contract, resulting in 193 forecasted observations.

Vuchelen and Gutierrez's (2005) original application of the direct tests focused on forecasted growth rates in seasonal macroeconomic measures. Not surprisingly, the price level of livestock follows seasonal patterns relating to seasonality in production. For instance, pork production tends to be lowest in the early summer, resulting in seasonally high prices for hogs during that period. Therefore, following Vuchelen and Gutierrez, this analysis focuses on seasonal differences defined as the log-relative change in price from the same month of the prior year. For example, let a_t equal the actual price in month t and f_t^{t+1} equal the one-step ahead forecast for that price. Recalling that there are six observations per year, the variables of interest are thus defined as the year-over-year percent change in actual prices, $A_t=\ln(a_t/a_{t-6})$, and the forecasted percent change in price, $F_t^{t+k}=\ln(f_t^{t+k}/a_{t+k-6})$ from the prior year.[3] The independent and dependent variables used in regression equation (5) were all found to be stationary using augmented Dickey Fuller tests.

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[2] There were occasions where the 12 month forward futures contract had not yet been listed or traded at the end of the forecast month. In these cases, the first traded price is used as the forecast. This occurred in 35 of the 193 cattle forecasts and 7 of the 193 hog forecasts. Due to their infrequency and relative stability of deferred futures pricing, it is unlikely that these observations have a material impact.

[3] The live hog futures ceased with the December 1996 contract. The February 1997 contract forward represents lean hog futures prices. The year-over-year actual and forecasted price changes in 1997 were calculated by after multiplying the lean hog futures price by the standard yield factor of 0.74.

Results

Equation (5c) was estimated for both live cattle and live hog futures forecasts at the two-, four-, six-, eight-, ten-, and twelve-month forecast horizons.[4] The coefficients are using OLS with the standard errors adjusted for overlapping horizons incorporating Hanson's procedure. From equation (5c), we test two alternative hypotheses. First, a rational and unbiased forecast is tested under the null hypothesis that $\beta_2=\beta_3=1$, $\beta_1=0$. Second, and the primary focus of this research, is a test of the null hypothesis of no incremental information at the forecast horizon, $\beta_3=0$. Thus, if null hypothesis is rejected, it suggests that there is indeed unique information contained in deferred futures price forecasts (k-step ahead forecasts) relative to the more nearby forecast (k-1 step ahead forecast).

The live cattle estimation results for (5c) at all forecast horizons are shown in table 1. At the two-month horizon, the null hypothesis of a rational forecast is rejected at the 5% level. Examining the individual coefficient estimates, it is clear that the rejection likely stems from a rejection that $\beta_3=1$ (5% level, two-tailed t-test). This would suggest that the two-month ahead futures forecasts are not properly scaled ($\beta<1$ in equation (1)). Hence, the futures market may not be efficiently incorporating information into the forecast (Nordhaus). However, there is little doubt that the two-month ahead forecast is providing some unique information, as $\beta_3=0$ is rejected at conventional significance levels. Therefore, at the two-month horizon, there is some evidence that the live cattle futures price forecast is inefficiently utilizing information; but, at the same time it is providing unique information to the marketplace.

At the four-month horizon, a rational null hypothesis is again rejected. Yet, the futures prices are providing incremental information not found in the two-month ahead forecast ($\beta_3=0$ rejected at the 5% level). This implies that the four-month ahead futures price is providing information not found in the two-month ahead live cattle futures price. For example at the end of January, the June live cattle futures price (four ahead) is providing unique information that cannot be obtained by simply using the April futures price (two ahead). Importantly, because this method is using year-over-year actual and forecasted changes, we are controlling for seasonality, which strengthens the result. The additional information provided by the futures forecasts is above and beyond a standard seasonal adjustment.

Similar results are found at the six, eight, and ten-month horizons for live cattle (table 1). That is, for each of these forecast horizons, forecast rationality is rejected yet they provide unique information. However, as evidenced by the declining magnitude of the estimated β_3 coefficient, the amount of unique information decays quickly beyond the eight-month horizon. At the eight-month horizon, the β_3 is estimated at a statistically significant 0.7048, and it declines to a still statistically significant 0.5496 at the ten-month horizon.

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[4] Because the time series are spaced at 60 (2 month) intervals, a one-step ahead forecast is a two-month ahead horizon. Therefore, the method must be applied to the two-, four-, six-, eight-, ten-, and twelve-month ahead horizons, representing the spacing of delivery months.

However, at the twelve-month horizon, β_3 is estimated at 0.2648, which is not statistically different from zero at the 5% level. So, the twelve-month ahead live cattle futures price is not providing any statistically significant information beyond that contained in the ten-month ahead futures price. This result is consistent with Irwin, Gerlow, and Liu who suggest that longer horizon livestock futures prices may not be providing a great deal of forecasting ability.

The results for the hog futures market are presented in table 2. Interestingly, the results for the hog futures market are markedly different from those obtained for live cattle (table 1). As shown in table 2, the two-month ahead hog futures prices are rational (β_2=β_3=1, β_1=0) and provide unique information ($\beta_3 \neq 0$). Indeed, across all horizons, there is a failure to reject the null rationality hypothesis at the 5% level. Moreover, at every horizon, we reject the null hypothesis that β_3=0, so unique information is being provided. Unlike the live cattle results, the hog futures prices show very little decay in the estimated β_3 across horizons. Only at the twelve-month horizon is there some visual decay in information with the estimated β_3 falling below 0.90, but still not statistically different from unity (5% level, 2-tailed, t-test). Also, at the twelve-month horizon, rationality is not rejected at the 5% level, but it is at the 10% level with a p-value of 0.0685. In the context of the presented tests, the results paint the hog futures market as being a rational assimilator of unique information at each forecast horizon.

Collectively the results portray a live cattle futures market that is not particularly rational, and the amount of unique information in prices falls quickly beyond the eight- month horizon. In stark contrast, in the hog futures market, the null rationality hypothesis is not rejected at any horizon (5% level), and there is unique information provided out to the twelve-month horizon. The difference in results between the live cattle and hog futures markets is somewhat surprising. The difference may relate to the alternative structure of each industry, the type and nature of public information, or potentially the design of the futures contracts themselves.

Summary and Conclusions

The marginal forecast information contained in deferred futures prices is evaluated using the direct test of Vuchelen and Gutierrez. The direct test is applied to live cattle and hog futures prices using even contract months from February 1975 through February 2007. Rationality could not be rejected in the hog futures market at any horizon (5% level), and the hog futures prices are providing unique information at each forecast horizon out to twelve months. In contrast, rationality is rejected in the live cattle futures market at each forecast horizon, and unique information seems to decline quickly beyond the eight-month horizon with no incremental information provided at the twelve-month horizon.

Generally, the overall results are somewhat better than might have been expected from some prior research. Earlier work, which focused on market efficiency tests, largely indicates that the livestock futures markets might see a decline in forecast efficacy beyond the six-month horizon (see Irwin, Gerlow, and Liu). In this regard, the presented results shed a somewhat favorable light on the performance of these markets. However, the poor performance of the live cattle futures market, relative to the hog futures market, is confounding.

Indeed, the live cattle futures market fails the rationality test at all horizons, and it shows a marked decline in information content beyond the eight-month horizon. In contrast, the hog futures market does not reject rationality at any horizon, and it provides unique information in even the most deferred prices. The stark difference in performance may stem from the structure of the industry coupled with the public data provided by the United States Department of Agriculture (USDA). For example, the primary supply data provided by the USDA for the live cattle market is the monthly *Cattle on Feed* report. Since cattle are in feedlots for roughly six months, it could be the case that the market has very good information about supplies (and subsequent prices) for six months hence, but more limited information beyond that contained in the report. Beyond that window, the lack of timely information, coupled with the relatively long beef production cycle, may make forecasting particularly difficult. At the minimum, it may be difficult for the market to assimilate unique information at alternative horizons beyond six to eight months. In the hog market, the primary supply data provided by the USDA is the quarterly *Hogs and Pigs* report. Unlike the *Cattle on Feed* reports, the *Hogs and Pigs* report not only contains current and intermediate inventory information, such as "market inventory", but it also contains information vital to longer-term supplies, such as "breeding inventory." Moreover, the *Hogs and Pigs* report provides explicit forward looking information in the form of "farrowing intentions." In this regard, the hog market may have a more rich information set available for making twelve-month forecasts than what is available to the live cattle futures market. As well, the farrow-to-finish production cycle is much shorter for hogs, perhaps allowing the hog futures market to better assimilate production information into more deferred futures prices.

It is important to note that the structure of both the cattle and hog marketing systems, as well as the futures markets, changed dramatically over the sample investigated. Structural shifts in these industries as well as evolution in contract specifications and design may be partially driving the results. Indeed, an important extension of this work will be to test for information in different sub periods throughout the sample.

From a practitioner's perspective, the hog results are encouraging. For those agribusinesses that use hog futures prices to make forecasts, they should continue to utilize futures quotes out to the twelve-month horizon. Each contract month is providing unique information and a rational forecast. More care must be taken in using the live cattle futures price for forecasts. These forecasts are not rational, and the information content drops quickly beyond the eight-month horizon. The futures-implied forecasts are quite possibly providing forecasts that are better than most alternatives. However, they need to be properly re-scaled to reflect rational forecasts.

The Chicago Mercantile Exchange (CME) may find this information useful when considering when to list deferred contracts. Current CME rules essentially allow new livestock futures contracts to start trading (or be listed) shortly after the same contract month of the prior year expires. This results in futures contracts being traded out for roughly twelve months. From an information perspective presented in this research, a twelve-month horizon for trading deferred live cattle futures is adequate, given that they provide no unique information beyond the ten-month horizon. However, for the hog futures market, the CME could consider listing contracts beyond twelve months with some confidence that the futures market would be providing unique information in these deferred prices. Ultimately, these longer-term, futures-implied forecasts could assist the industry through improved decision-making.

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Table 1. Information Test, Live Cattle, $A_{t+k} = \beta_1 + \beta_2 F_t^{t+k-1} + \beta_3 (F_t^{t+k} - F_t^{t+k-1}) + u_{t+k}$

Coefficients	2 month	4 month	6 month	8 month	10 month	12 month
β_1	0.0061[a]	0.0136	0.0182	0.0229	0.0258	0.0270
	(0.0050)[b]	(0.0072)	(0.0095)	(0.0121)	(0.0141)	(0.0154)
β_2	0.9769	0.9517	0.8956	0.6810	0.6333	0.5410
	(0.0689)	(0.1034)	(0.1348)	(0.1572)	(0.1590)	(0.1917)
β_3	0.7682	0.7275	0.7335	0.7048	0.5496	0.2648
	(0.0884)	(0.0789)	(0.0905)	(0.0923)	(0.1254)	(0.1642)
$\beta_2=\beta_3=1$, $\beta_1=0$	0.0111[c]	0.0000	0.0001	0.0011	0.0004	0.0000
$\beta_3=0$	0.0000[c]	0.0000	0.0000	0.0000	0.0000	0.1086

[a]Estimated coefficient.
[b]Standard error in parenthesis.
[c]P-value for stated restriction.

Table 2. Information Test, Live Hogs, $A_{t+k} = \beta_1 + \beta_2 F_t^{t+k-1} + \beta_3 (F_t^{t+k} - F_t^{t+k-1}) + u_{t+k}$

Coefficients	2 month	4 month	6 month	8 month	10 month	12 month
β_1	0.0041[a]	0.0133	0.0209	0.0266	0.0356	0.0394
	(0.0074)[b]	(0.0110)	(0.0150)	(0.0184)	(0.0211)	(0.0220)
β_2	1.002	0.9964	0.9857	0.9402	0.9655	0.9861
	(0.0389)	(0.0614)	(0.0985)	(0.1271)	(0.1380)	(0.1600)
β_3	0.9516	0.9308	0.9103	0.9410	0.9145	0.8501
	(0.0808)	(0.0689)	(0.0736)	(0.0883)	(0.1082)	(0.1183)
$\beta_2=\beta_3=1$, $\beta_1=0$	0.7784[c]	0.3909	0.1989	0.4020	0.2389	0.0685
$\beta_3=0$	0.0000[c]	0.0000	0.0000	0.0000	0.0000	0.0000

[a]Estimated coefficient.
[b]Standard error in parenthesis.
[c]P-value for stated restriction.