Cash Settlement and Price Discovery in Futures Markets

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This paper examines how cash settlement affects the ability of the futures market to predict future spot prices. Adopting the Geweke feedback measure, we find that the feeder cattle futures contract improved its price discovery function after the cash settlement was adopted in August 1986. Moreover, spot and futures markets became more integrated thereafter. We also consider the case in which the cash-settled lean hog futures contract replaced the physical delivery-settled live hog futures contract in December 1996. Herein the conclusion is drastically different. After cash settlement was adopted, the futures market was less effective in price discovery. Further, spot and futures markets were more segmented.

Introduction

Traditionally, commodity futures contracts are settled by physical delivery. A seller with an open position at contract expiration must make deliveries to liquidate the position. Similarly, a buyer must take deliveries to liquidate an open position held at the contract maturity. In spite of high transportation, inspection, and storage costs, this settlement specification was adopted to ensure the convergence between spot and futures prices at the contract expiration date. Moreover, to ensure the adequacy of the delivery mechanism (en route to reduce market manipulations such as corners and squeezes), most contracts allow the seller to choose among multiple deliverable grades and locations (at predetermined discounts and premiums). As a result, the futures price will converge to the cheapest deliverable grade. This creates additional uncertainty, the so-called delivery risk, which leads to a larger basis risk

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(Leuthold, 1992). The risk transferring and price discovery functions of a futures market are damaged.

Since the advent of stock index futures contracts in 1982, the Commodity Futures Commission (CFTC) allows for the possibility of cash settlement specifications. Under this system, a futures contract is settled by a cash payment transfer. The payment is dictated by a cash index. Consequently, the effectiveness of a cash-settled futures contract hinges on the construction of a reasonable index. This, of course, is not an easy task. For example, a narrow-based index consisting of a small number of grades and locations is subject to manipulation, whereas a broad-based index reduces the hedging effectiveness. An optimal index (in terms of liquidity or trading volume) should reflect the market conditions. Heterogeneity and non-storability of agricultural commodities create difficulties in constructing an appropriate cash index. As a result, commodity futures contracts continue to rely for the most part on physical delivery settlement. The only two exceptions are feeder cattle and lean hogs futures.

Previous work concentrates on the change in hedging effectiveness in response to cash settlement adoption. It has been found that cash settlement improved the hedging function of both futures contracts; see, for examples, Kenyon, Bainbridge, and Ernst (1991); Rich and Leuthold (1993); Kimle and Hayenga (1994); Ditsch and Leuthold (1996); Lien and Tse (2002); and Chan and Lien (2002, 2003). This paper, instead, analyzes the effects of cash settlement on the price discovery function of a futures market as applied to both feeder cattle and live/lean hog cases. More specifically, the feedback measures proposed by Geweke (1982) will be used to compare the relationships between spot and futures prices before and after cash settlement was in place.

Literature Review

The feeder cattle futures contract changed to cash settlement in September 1986. Since then there have been a number of studies examining its impacts, and these studies have concluded with mixed results. Noting that the cash-settled feeder contract is based upon the U.S. Feeder Steers Price (USFSP), earlier work investigates the effect of cash settlement in the contract maturity period during which the cash index provided a good approximation of the futures price. With Arkansas auction data as the cash price and USFSP as a proxy for cash settlement, Elam (1988) finds significant reduction in the use of the contract to hedge risk for the September, October, and November contracts. Schroeder and Mintert (1988) extend the above analysis to price data of Amarillo, Kansas City, Dodge, and Illinois Direct. While Amarillo, Kansas City, and Dodge City are three of the twenty-seven reporting stations included in USFSP, Illinois Direct is not. Hedging risk was reduced in all the four markets, with the greatest reduction for steers that meet the contract weigh specifications. Note that both Elam (1988) and Schroeder and Mintert

(1988) adopt the cash index as a proxy for the futures price, an approach that may be reliable only during the maturity month.

Kenyon, Bainbridge, and Ernst (1991) apply actual post cash settlement futures price data. Using Oklahoma City and Southwest Virginia auction data as cash prices, they find the basis variance was smaller after the introduction of cash settlement when compared to physical delivery. However, the reductions in variance are not statistically significant. An analysis of the basis forecasting error, using Virginia data, also suggests that cash settlement provides little improvement. On the other hand, cash and futures prices have become more highly correlated since the adoption of cash settlement.

Rich and Leuthold (1993) perform a more comprehensive study, using data from 27 price reporting stations and a longer post cash settlement futures price data series. For most markets, they find only modest improvement in basis variability but a significantly smaller basis after cash settlement. Thus, the convergence between futures and cash prices has improved since cash settlement, making the futures contract a better hedging instrument.

All the above studies assume a constant volatility, an assumption rejected by Lien and Tse (2002). When applying either GARCH (Generalized Autoregressive Conditional Heteroskedasticity) or stochastic volatility models, however, cash settlement once again was found to be beneficial to futures hedging (Lien and Tse, 2002; Chan and Lien, 2002).

For the live/lean hogs futures contract, Kimle and Hayenga (1994) notice significant decline in trading volume at the terminal markets. They interpret the observations as possible structural changes in the hog market and question the feasibility of continuing physical delivery for the live hog futures contract. Adopting simulated data, it was found that cash settlement would provide better convergence between cash and futures prices and that basis variability would be significantly reduced. Ditsch and Leuthold (1996) construct optimal hedge ratios from the simulated data. They suggest that the lean hog futures contract would provide better hedging effectiveness than the live hog futures contract.

Little has been said in the literature concerning the effect of cash settlement on the price discovery function of the futures market. This paper addresses this question using the feedback measures proposed by Geweke (1982). The methodology is described in the next section.

Statistical Methodology

Let S_t and F_t denote the logarithms of spot and futures prices, respectively. We adopt a vector autoregression model with error-correction. Let Δ be the difference operator such that $\Delta S_t = S_t - S_{t-1}$ and $\Delta F_t = F_t - F_{t-1}$, and let $B_t = S_t - F_t$ be the basis. We have the following equations:

$$\Delta S_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \Delta F_{t-i} + \delta_S B_{t-1} + \varepsilon_{St}, \tag{1}$$

$$\Delta F_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta S_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta F_{t-i} + \delta_F B_{t-1} + \varepsilon_{Ft}, \tag{2}$$

where the variance/covariance matrix of $(\varepsilon_{St}\varepsilon_{Ft})$ is

$$\Sigma = \operatorname{cov}\begin{bmatrix} \varepsilon_{St} \\ \varepsilon_{Ft} \end{bmatrix} = \begin{bmatrix} \sigma_S^2 & \sigma_{SF} \\ \sigma_{FS} & \sigma_F^2 \end{bmatrix}.$$

If, instead, there is no intertemporal relationship between spot and futures prices, then equations (1) and (2) are reduced to

$$\Delta S_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta S_{t-i} + u_{St}, \tag{3}$$

$$\Delta F_t = \beta_0 + \sum_{i=1}^{n} \beta_{2i} \Delta F_{t-i} + u_{Ft}, \tag{4}$$

with $\operatorname{var}(u_{St}) = \sigma_{uS}^2$ and $\operatorname{var}(u_{Ft}) = \sigma_{uF}^2$. The equation system (1)-(2) can be estimated by seemingly unrelated regression method, whereas, the equation system (3)-(4) can utilize the ordinary least squares method. Let $\hat{\Sigma}$ denote the estimated variance-covariance matrix of $(\varepsilon_{St}\varepsilon_{Ft})$ and let $\hat{\sigma}_{uS}^2$ and $\hat{\sigma}_{uF}^2$ denote the estimators of σ_{uS}^2 and σ_{uF}^2 from equations (3) and (4), respectively.

Following Geweke (1982), linear dependence (or total information flow) between spot and futures prices is measured as follows:

$$\hat{F}_{S,F} = \ln[\hat{\sigma}_{uS}^2 \times \hat{\sigma}_{uF}^2 / \det(\hat{\Sigma})], \tag{5}$$

where det(.) denotes the determinant operator. Moreover, the linear feedback from spot to futures prices is measured by:

$$\hat{F}_{S\to F} = \ln(\hat{\sigma}_{uF}^2 / \hat{\sigma}_F^2). \tag{6}$$

Similarly, the linear feedback from futures to spot prices is measured by:

$$\hat{F}_{F\to S} = \ln(\hat{\sigma}_{uS}^2 / \hat{\sigma}_S^2). \tag{7}$$

Define the instantaneous linear feedback measure between the two prices as follows:

$$\hat{F}_{S\leftrightarrow F} = \ln(\hat{\sigma}_S^2 \times \hat{\sigma}_F^2 / \det\hat{\Sigma}). \tag{8}$$

Then we have $\hat{F}_{S,F} = \hat{F}_{S\to F} + \hat{F}_{F\to S} + \hat{F}_{S\leftrightarrow F}$.

In fact, $\hat{F}_{S,F}$ is the test statistic with the following restrictions: $\delta_S = \delta_F = \sigma_{SF} = 0$, and $\alpha_{2i} = \beta_{1i} = 0$, i = 1, … , n. More specifically, $N\hat{F}_{S,F}$ is chi-square distributed with $2n+3$ degrees of freedom. Under the null hypotheses, there is no information flow between spot and futures prices. The statistic $\hat{F}_{S\to F}$ tests the restrictions $\delta_S = 0$ and $\alpha_{2i} = 0$, i = 1, … , n; that is, the futures price has no effect on the behavior of the spot price. Similarly, $\hat{F}_{F\to S}$ tests the restrictions $\delta_F = 0$ and $\beta_{1i} = 0$, i = 1, … , n in order to examine the hypothesis that the spot price has no effect on the behavior of the futures price. Let N denote the sample size. Both $N\hat{F}_{S\to F}$ and $N\hat{F}_{F\to S}$ are chi-square distributed with $n+1$ degrees of freedom. When $N\hat{F}_{S\to F}$ is statistically significant but $N\hat{F}_{F\to S}$ is not, we conclude that the spot price leads the futures price. If, instead, $N\hat{F}_{F\to S}$ is statistically significant but $N\hat{F}_{S\to F}$ is not, then the futures price is said to lead the spot price. The price discovery function of the futures price is summarized by $\hat{F}_{F\to S}$. A larger $\hat{F}_{F\to S}$ implies that the futures price serves its discovery function more effectively. By comparing $\hat{F}_{F\to S}$ for pre- and post-cash settlement periods, we can evaluate the effect of the cash settlement on the price discovery function of the futures market.

Finally, $\hat{F}_{S\leftrightarrow F}$ is the test statistics for the restriction $\sigma_{SF} = 0$, and $N\hat{F}_{S\leftrightarrow F}$ is chi-square distributed with one degree of freedom. A larger $\hat{F}_{S\leftrightarrow F}$ indicates a stronger contemporaneous relationship between spot and futures prices through the co-movement of the shocks to the two markets. If cash settlement promotes hedging interests, the larger trading volume would facilitate information flows between spot and futures markets. Consequently, we expect both $\hat{F}_{S\leftrightarrow F}$ and $\hat{F}_{S,F}$ to increase after cash settlement is in place.

Data Description

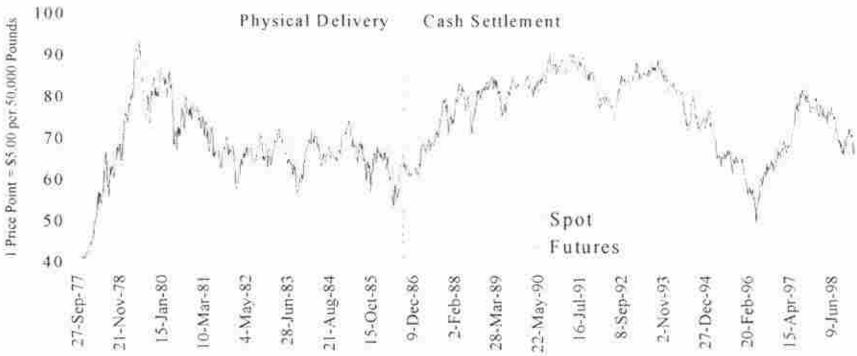
We obtain cash and futures price data for feeder cattle from the Commodity System Inc. covering the period from September 1977 to December 1998. Cash price is referred to as the seven-day average of 600-700 lb. feeder cattle price at Oklahoma City. The contract months for feeder cattle futures are January, March, April, May, August, September, October, and November. We use the Tuesday cash price and nearby futures price data. When Tuesday data are not available, Monday data are adopted. Nearby futures contracts are rolled over to the next [delivery contract month] at about three weeks before maturity. The feeder cattle contract changed to cash settlement in August 1986. In total, we have 463 observations for the physical delivery period and 637 observations for the cash settlement period.

Figure 1 displays the full date sample, and Table 1 provides summary statistics for feeder cattle data. The most evident change applies to the standard deviation for both returns and the basis. After the cash settlement, the standard deviation for the spot and futures returns declined from 2.505 and 2.610 to 1.290 and 1.626, respectively. The standard deviation of the basis also decreased from 3.999 to 2.094. Both spot and futures markets appear more stable during the cash settlement period.

Table 1—Summary Statistics for Feeder Cattle Futures

	Physical Delivery Period (9/01/77 – 7/29/86)			Cash Settlement Period (8/05/86 – 12/31/98)		
Statistics	Spot Return	Futures Return	Basis (%)	Spot Return	Futures Return	Basis (%)
Mean	0.083	-0.020	0.536	0.015	0.088	0.509
Standard. Deviation	2.505	2.610	3.999	1.290	1.626	2.094
Skewness	-0.282	0.102	0.153	0.004	-0.098	-0.502
Excess Kurtosis	1.877	0.614	0.140	1.971	1.437	1.059
Minimum	-10.767	-8.354	-12.48	-5.839	-6.818	-8.489
Maximum	9.885	9.319	14.04	5.869	7.063	5.970

Figure 1—Feeder Cattle Prices, Spot and Futures Weekly, September 1977 to December 1998



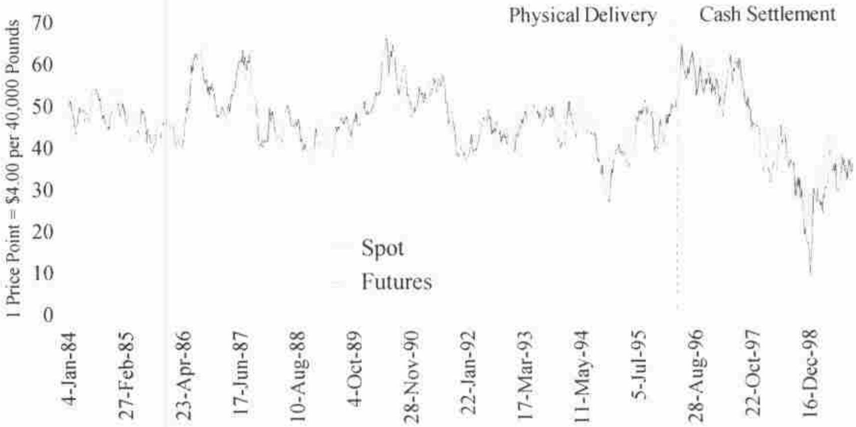
Cash and futures price data for live/lean hogs are obtained from the Futures Industry Institute. The data cover the period between January 1984 and October 1999. The live hogs futures contract were replaced by the lean hogs futures contract starting in December 1996. This leaves us with 671 weekly observations before cash settlement and 152 weekly observations after cash settlement was adopted. We select spot and futures prices from each Wednesday. When they are not available, Tuesday data are used instead.

Summary statistics for live/lean hog data are described in Table 2, and Figure 2 displays the full data sample. Contrary to the feeder cattle case, the market appears to be more volatile after the futures contract switched from physical delivery to cash

Table 2—Summary Statistics for Live/Lean Hogs Futures

	Live Hogs Futures Period (1/04/84 – 11/29/96)			Lean Hogs Futures Period (12/06/96 – 10/29/99)		
Statistics	Spot Return	Futures Return	Basis (%)	Spot Return	Futures Return	Basis (%)
Mean	0.021	0.327	-2.629	-0.317	-0.333	-8.977
Standard. Deviation	3.601	2.715	6.166	9.871	26.181	12.832
Skewness	-0.088	-0.021	0.150	0.675	1.058	-2.024
Excess Kurtosis	0.378	0.537	0.575	11.294	4.807	7.288
Minimum	-11.955	-8.917	-22.915	-51.083	-16.359	-83.209
Maximum	11.054	10.075	19.685	54.362	26.181	11.763

Figure 2—Live/Lean Hog Prices, Spot and Futures Weekly, January 1984 to October 1999



settlement. The standard deviation for spot and futures returns increased from 3.601 to 9.871 and 2.715 to 26.181, respectively. There is also a drastic increase in the volatility of the basis, from 6.166 to 12.832. A similar pattern applies to the kurtosis, reinforcing the possible destabilizing nature of cash settlement in live/lean hog futures contracts.

Empirical Results: Feeder Cattle

To support the error correction specification, unit root and cointegration tests are applied to all the price data series. Results are available upon request. Table 3 presents estimation results for the equation system (1)-(2), and we also note that AIC are applied to choose the optimal lag. During the physical delivery period, the spot return was negatively affected by the previous spot return, displaying a mean reversion pattern. A large previous futures return promoted the current spot return whereas a large previous basis depressed the current spot return. The latter is predicted by basis convergence. On the other hand, the futures return behaved more like a random walk. The estimation results indicate that the futures lead the spot market in feeder cattle during the physical delivery period.

After cash settlement was adopted, the spot return was affected by spot and futures returns of the previous three weeks. Basis also produced a stronger impact on the spot return. Meanwhile, the futures return was now positively affected by the

Table 3—Structural Relationships between Feeder Cattle Spot and Futures Returns

The structural equations are:

$$\Delta S_t = \alpha_0 + \sum_{i=1}^{n}\alpha_{1i}\Delta S_{t-i} + \sum_{i=1}^{n}\alpha_{2i}\Delta F_{t-i} + \delta_S B_{t-1} + \varepsilon_{St}, \text{ and } \Delta F_t = \beta_0 + \sum_{i=1}^{n}\beta_{1i}\Delta S_{t-i} + \sum_{i=1}^{n}\beta_{2i}\Delta F_{t-i} + \delta_F B_{t-1} + \varepsilon_{Ft},$$

where $\Delta S_t = S_t - S_{t-1}$ is the weekly change of feeder cattle cash price, $\Delta F_t = F_t - F_{t-1}$ is the weekly change of feeder cattle futures price, and $B_t = S_t - F_t$ is the basis

	Physical Delivery Period		Cash Settlement Period	
Variable	Spot Return	Futures Return	Spot Return	Futures Return
Constant	0.219	-0.013	0.067	0.033
	(2.052)	(-0.109)	(1.711)	(0.477)
ΔS_{t-1}	-0.302**	0.004	-0.245**	-0.129
	(-5.708)	(0.063)	(-5.422)	(-1.63)
ΔS_{t-2}			-0.060	0.059
			(-1.516)	(0.852)
ΔS_{t-3}			0.057	0.027
			(1.903)	(0.504)
ΔF_{t-1}	0.442**	0.086	0.574**	0.039
	(9.314)	(1.571)	(22.58)	(0.876)
ΔF_{t-2}			0.162**	0.066
			(5.078)	(1.180)
ΔF_{t-3}			0.060	0.086
			(1.964)	(1.606)
B_{t-1}	-0.179**	-0.012	-0.220**	0.088**
	(-6.218)	(-0.370)	(-9.331)	(2.131)

The value in the parenthesis is the corresponding t-statistic
**Denotes statistically significant at the 5 percent level

Table 4—Individual Equation Estimates: Feeder Cattle

The equations are:

$$\Delta S_t = \alpha_0 + \sum_{i=1}^{n}\alpha_{1i}\Delta S_{t-i} + u_{St}, \text{ and } \Delta F_t = \beta_0 + \sum_{i=1}^{n}\beta_{2i}\Delta F_{t-i} + u_{Ft},$$

where $\Delta S_t = S_t - S_{t-1}$ is the weekly change of feeder cattle cash price and $\Delta F_t = F_t - F_{t-1}$ is the weekly change of feeder cattle futures price

	Physical Delivery Period		Cash Settlement Period	
Variable	Spot Return	Futures Return	Spot Return	Futures Return
Constant	0.085	-0.022	0.012	0.087
	(0.704)	(-0.164)	(0.179)	(1.270)
ΔS_{t-1}	0.033		0.319	
	(0.709)		(8.096)	
ΔS_{t-2}			-0.117	
			(-2.846)	
ΔS_{t-3}			0.096	
			(2.429)	
ΔF_{t-1}		0.089		0.024
		(0.047)		(0.599)
ΔF_{t-2}				-0.050
				(-1.260)
ΔF_{t-3}				0.094
				(2.364)

The value in the parentheses is the corresponding t-statistic basis. That is, a feedback effect was present between spot and futures markets during the cash settlement period. Estimates for equations (3) and (4) are provided in Table 4. Because these equations are incorrectly specified, interpretations of estimation results should be treated with caution. For example, due to omitted variable biases, the spot return may be wrongly concluded to follow a random walk for the physical delivery period.

Geweke feedback measures are presented in Table 5. During the physical delivery period, the instantaneous feedback between spot and futures markets is estimated to be 0.3494. When multiplied by the number of observations, it exceeds the 1 percent critical values of the $\chi^2(1)$ distribution. Thus, there exists a statistically significant instantaneous feedback. The estimated total feedback is 0.5515. Upon multiplying it by the number of observations and comparing the result to the 1 percent critical value of the $\chi^2(5)$ distribution, we conclude a statistically significant total feedback between spot and futures markets.

Table 5—Feedback Measures: Feeder Cattle

Linear dependence (or total information flow) between spot and futures prices is measured as follows: $\hat{F}_{S.F} = \ln[\hat{\sigma}^2_{uS} \times \hat{\sigma}^2_{uF} / \det(\hat{\Sigma})]$, where det(.) denotes the determinant operator. The linear feedback from spot to futures prices is measured by: $\hat{F}_{S\to F} = \ln(\hat{\sigma}^2_{uF} / \hat{\sigma}^2_{F})$. Similarly, the linear feedback from futures to spot prices is measured by: $\hat{F}_{F\to S} = \ln(\hat{\sigma}^2_{uS} / \hat{\sigma}^2_{S})$. Define the instantaneous linear feedback measure between the two prices as follows: $\hat{F}_{S\leftrightarrow F} = \ln(\hat{\sigma}^2_{S} \times \hat{\sigma}^2_{F} / \det \hat{\Sigma})$, then we have $\hat{F}_{S.F} = \hat{F}_{S\to F} + \hat{F}_{F\to S} + \hat{F}_{S\leftrightarrow F}$

	Physical Delivery	Cash Settlement
$\hat{F}_{S\leftrightarrow F}$	0.3494**	0.2406**
$\hat{F}_{S\to F}$	-0.0040	0.0187**
$\hat{F}_{F\to S}$	0.2060**	0.6050**
$\hat{F}_{S.F}$	0.5514**	0.8644**

**Indicates significant at the 1 percent level

The parameters of particular interest are the feedback from spot to futures markets and that from futures to spot markets. The estimates are 0.0040 and 0.2060, respectively. Based upon the $\chi^2(2)$ distribution, we find the latter to be statistically significant at the 1 percent level, while the former is not significant at any conventional level. The result indicates that the futures markets lead the spot market. The futures return helps predict the spot return (i.e., serves the price discovery function), whereas, the spot return does not improve the forecast of the futures return.

With the exception of instantaneous feedback, all three other feedback measures increase after the cash settlement was adopted. The value of $\hat{F}_{S\to F}$ increased from 0.0040 to 0.0187. Based upon the critical value of the $\chi^2(4)$ distribution, the latter is statistically significant at the 1 percent level. That is, after cash settlement the spot return helps predict the futures return. In the meantime, the value of $\hat{F}_{F\rightarrow S}$ also increased, from 0.2060 to 0.6050. Both are statistically significant at the 1 percent level. The increase in the feedback, however, indicates that the price discovery function of the feeder cattle futures contract is more effective under cash settlement than it was under physical delivery settlement. Finally, the total feedback increased from 0.5515 to 0.8643, suggesting a greater information flow between spot and futures markets during the cash settlement period. The two markets become more integrated. Better price discovery and more integration both benefit market participants. We conclude that the switching from physical delivery to cash settlement in feeder cattle futures indeed contributed to market performance.

Table 6—Structural Relationships between Live/Lean Hogs Spot and Futures Returns

The structural equations are:

$$\Delta S_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta S_{t-i} + \sum_{i=1}^{n} \alpha_{2i} \Delta F_{t-i} + \delta_S B_{t-1} + \varepsilon_{St}, \quad \Delta F_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta S_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta F_{t-i} + \delta_F B_{t-1} + \varepsilon_{Ft},$$

where $\Delta S_t = S_t - S_{t-1}$ is the weekly change of live/lean hog cash price, $\Delta F_t = F_t - F_{t-1}$ is the weekly change of live/lean hog futures price, and $B_t = S_t - F_t$ is the basis

	Live Hogs		Lean Hogs	
Variable	Spot Return	Futures Return	Spot Return	Futures Return
Constant	-0.612**	0.470**	-2.582**	-0.684
	(-4.412)	(4.177)	(-2.643)	(-1.131)
ΔS_{t-1}	-0.067	0.079**	0.069	0.076
	(-1.637)	(2.358)	(0.680)	(1.215)
ΔF_{t-1}	0.358**	0.059	-0.030	-0.153
	(6.576)	(1.341)	(-0.183)	(-1.496)
B_{t-1}	-0.199**	0.062**	-0.246**	-0.038
	(-9.694)	(3.696)	(-3.743)	(-0.927)

The value in the parentheses is the corresponding t-statistic

**Denotes statistically significant at the 5 percent level

Empirical Results: Live/Lean Hogs

Estimation results for the equation system (1)-(2) are presented in Table 6, where once again AIC are applied to choose the optimal lag. For the live hog contract period, the previous futures return has a positive impact, whereas the lagged basis has a negative effect on the current spot return. On the other hand, an increase in either the previous spot return or in the lagged basis promotes the current futures return. The impacts of basis on both returns are predicted by the basis convergence. There is a two-way lead-lag relationship between spot and futures returns. During the lean hog period, the spot return receives the impact only from the basis, and the futures return behaves like a random walk. Thus, the lean hog futures market leads the spot market. It appears that after cash settlement was adopted, the information flow between the two markets was reduced.

Table 7 presents the individual equation estimates, from which we calculate the Geweke feedback measures. Table 8 provides the Geweke results. For the live hog

Table 7—Individual Equation Estimates: Live/Lean Hogs

The equations are:

$$\Delta S_t = \alpha_0 + \sum_{i=1}^{n} \alpha_{1i} \Delta S_{t-i} + u_{St}, \text{ and } \Delta F_t = \beta_0 + \sum_{i=1}^{n} \beta_{2i} \Delta F_{t-i} + u_{Ft}.$$

where $\Delta S_t = S_t - S_{t-1}$ is the weekly change of live/lean hog cash price and $\Delta F_t = F_t - F_{t-1}$ is the weekly change of live/lean hog futures price

	Live Hogs		Lean Hogs	
Variable	Spot Return	Futures Return	Spot Return	Futures Return
Constant	0.027	0.329	-0.365	-0.317
	(-4.412)	(2.794)	(-0.455)	(-0.705)
ΔS_{t-1}	0.069		-0.013	
	(1.794)		(0.876)	
ΔF_{t-1}		0.115		-0.075
		(2.989)		(-0.910)

The values in parentheses are the corresponding t-statistics

futures period, the estimates of $\hat{F}_{S\to F}$ and $\hat{F}_{F\to S}$ are 0.0253 and 0.1813, respectively. Based upon the $\chi^2(2)$ distribution, we find both to be significant at the 1 percent level. Either return improves the forecasting accuracy of the other return. The instantaneous feedback accounts for a greater share of the total feedback. That is, both spot and futures markets respond to new information simultaneously. Beyond that, the fact that $\hat{F}_{F\to S}$ is larger than $\hat{F}_{S\to F}$ signals that the future market plays more of a leading role while the spot market tends to follow.

We now turn to the cash-settled lean hogs futures market. Both $\hat{F}_{S\to F}$ and $\hat{F}_{F\to S}$ decreased, from 0.0253 to 0.0017 and 0.1813 to 0.0791 respectively, when compared to the physical delivery period. Not only did the feedback from spot to futures markets decline, it was no longer statistically significant at any conventional level. The reduction in the futures-to-spot feedback measure implies that the discovery function of the future market has dwindled. Although the instantaneous feedback increased a little, the total feedback actually decreased nearly 15 percent, from 0.6787 to 0.5699. In other words, after cash settlement was adopted, spot and futures markets react more responsively and quickly to the new information. While the futures market still plays more of the leading role to the spot market, its importance has diminished considerably. Beyond responding simultaneously to the arrival of new information, there is little information flow between the two markets. Contrary to the feeder cattle case, we find that cash settlement led to poorer market performance.

What can explain these contradicting conclusions? In general, we suggest the conclusions for the live/lean hog case be treated with caution. First, the sample size is small. There are 152 observations for the lean hog futures contracts. Because Geweke measures are large sample properties, the small sample size for the hog study casts doubts on the reliability of the empirical results. Second, along with the change from physical delivery to cash settlement, the lean hog futures contract also adopts a different weighing scheme from the live hog futures. While the live weight

Table 8—Estimates for the Feedback Measures: Live/Lean Hogs

Linear dependence (or total information flow) between spot and futures prices is measured as follows: $\hat{F}_{S,F} = \ln[\hat{\sigma}_{uS}^2 \times \hat{\sigma}_{uF}^2 / \det(\hat{\Sigma})]$, where det(.) denotes the determinant operator. The linear feedback from spot to futures prices is measured by: $\hat{F}_{S\to F} = \ln(\hat{\sigma}_{uF}^2 / \hat{\sigma}_F^2)$. Similarly, the linear feedback from futures to spot prices is measured by: $\hat{F}_{F\to S} = \ln(\hat{\sigma}_{uS}^2 / \hat{\sigma}_S^2)$. Define the instantaneous linear feedback measure between the two prices as follows: $\hat{F}_{S\leftrightarrow F} = \ln(\hat{\sigma}_S^2 \times \hat{\sigma}_F^2 / \det \hat{\Sigma})$, then we have $\hat{F}_{S,F} = \hat{F}_{S\to F} + \hat{F}_{F\to S} + \hat{F}_{S\leftrightarrow F}$. The sub-sample removes the first three-month observations of the lean hog futures contract

	Live Hogs	Lean Hogs	Lean Hogs Sub-Sample
$\hat{F}_{S\leftrightarrow F}$	0.4721**	0.4925**	0.4954**
$\hat{F}_{S\to F}$	0.0253**	-0.0017	-0.0005
$\hat{F}_{F\to S}$	0.1813**	0.0791**	0.0773**
$\hat{F}_{S,F}$	0.6787**	0.5699**	0.5722**

**Indicates significance at the 1 percent level

was applied previously, the new contract adopted carcass weights. On average, one pound of live weight equals to 0.74 pound of carcass weight. However, the exact conversion factor varies from case to case. As the spot price continues to rely on the live weight, there are additional uncertainties concerning the relationships between spot and lean hog futures prices, which adversely affect futures market performance.

The CME perceives that the change from live weight to carcass weight is major and critical. Therefore, the live hog futures contract is abandoned and replaced by the lean hog futures contract. On the other hand, for the feeder cattle contract, the only change is in the settlement specification. It is not perceived to be a major change. Consequently, the name of the contract is reserved, and we merely have a cash-settled feeder cattle futures contract replace a physical delivery feeder cattle futures contract. Market participants therefore are likely to treat the lean hog futures contract as a new contract instead of a different live cattle futures contract. The comparisons between the performance of live hog and lean hog futures contracts therefore do not provide a meaningful observation to evaluate the effect of cash settlement method.

If the lean hog futures contract is considered a new contract by market participants, then there will be a learning period during which the market behavior is aberrant. To account for this consideration, we examine a sub-sample removing the data from the first three months observations of the lean hog futures contract. The results are presented in columns 4 of Table 8. There is no qualitative difference between Geweke measures for the whole sample and the sub-sample. Thus, our conclusions concerning the live and lean hog futures market comparisons remain valid. That is, the price discovery function in the lean hog futures market is worse than that in the live hog futures market. The switch from physical delivery to cash settlement, however, may not be responsible for the results.

Conclusions

This paper examines how cash settlement affects the ability of the futures market to predict future spot prices. Adopting the Geweke feedback measure, we find that the feeder cattle futures contract improved its price discovery function after the cash settlement was adopted in August 1986. Moreover, spot and futures markets became more integrated thereafter.

We also consider the case in which the cash-settled lean hog futures contract replaced the physical delivery-settled live hog futures contract in December 1996. Herein the conclusion is drastically different. After cash settlement was adopted, the futures market is less effective in price discovery. Further, spot and futures markets are more segmented. We suspect other contract uncertainties, including the change in weighing scheme, give rise to the undesirable results. As the names of the contracts are different, live hog and lean hog futures contracts are likely perceived to be two different contracts. Comparisons between the performance of the two contracts my not provide a meaningful observation to evaluate the effect of cash settlement method.

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