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THE LIVE CATTLE FUTURES MARKET AND DAILY CASH PRICE MOVEMENTS

by

B. Wade Brorsen

Charles M. Oellermann

Paul L. Farris

Cattle trade -- Futures

B. Wade Brorsen is an Associate Professor of Agricultural Economics, Purdue University. Charles M. Oellermann is staff economist for the U.S. Senate Committee on Agriculture, Nutrition, and Forestry. Paul L. Farris is Professor of Agricultural Economics, Purdue University.

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ABSTRACT

Comparative static results suggest that if futures markets improve cash market efficiency as expected then the variance of cash prices should increase. Empirical results with live cattle confirm the theoretical model. Cash prices for live cattle at Omaha showed increased daily variability after live cattle futures trading began on the Chicago Mercantile Exchange. The speed with which changes occurred were also greater after the advent of futures trading. The results imply greater cash market efficiency with futures but more large short-run price changes.

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Futures trading has frequently been perceived by the public to "adversely" influence cash prices. The live cattle futures in particular have been criticized. Although some have argued that futures trading can lower the average level of cash prices (Wise, 1962; Bagnell, 1963), a more common belief is that futures markets tend to destabilize cash prices and thus increase the risk faced by producers. Most past research, however, is inconsistent with this belief.

Past studies have generally concluded that futures trading either reduced variability or had no significant effect. An explanation of the reduced variability is that the futures market either decreased risk or improved information so that more optimal storage or production decisions were made, which tended to stabilize prices. Only Figlewski found that price variability increased in the presence of a futures market. Figlewski was unable to offer a satisfactory explanation of his findings and his conclusions have been seriously questioned by subsequent work (Committee on Agriculture, p. 204). Past empirical research on the effects of futures markets on cash prices has generally used some measure of the variance of weekly or monthly cash prices (e.g., Working, 1960; Gray, 1963; Johnson, 1968; Emerson and Tomek, 1969; Tomek, 1971; Taylor and Leuthold, 1974; Figlewski, 1981).[1] None considered daily price variability, which is studied in this paper. Several theoretical studies have also examined the effects of futures on cash markets, but they have all assumed prices were in equilibrium (see Committee on Agriculture (1985) for a review of these studies.)

The live cattle market has been examined the most extensively. Powers (1970) discovered a statistically significant reduction in the random component of weekly price variability after futures trading began. Taylor and Leuthold (1974) found variances of monthly and weekly cash prices decreased significantly after futures trading began. Tomek (1979-80, p. 358) analyzed weekly prices and concluded, "the existence of futures trading appears not to have a measurable effect on the variation of the stochastic component of cattle and hog prices." More recently, the Chicago Mercantile Exchange (1986) verified past results using weekly data, concluding (p. 6), "the evidence suggests that the futures market has decreased rather than increased the volatility of cash prices and that this takes place through stabilizing placement activity."

This past empirical research suggests that the futures market either has had no effect on the variance of cash prices or has reduced the variance of cash prices. This past research has defined variability in a variety of ways, but it has always looked at long-term measures of variability (monthly or weekly) and has not looked at variability in the very short run (daily).[2] Also, little research has addressed the effects of futures markets on the speed of adjustment of cash prices. Cox (1976) presented theoretical and empirical arguments that cash price adjustments were faster and thus cash markets were more efficient after futures markets were introduced. If cash prices are in short-run disequilibrium in the absence of a futures market as Cox suggested then the effects of introducing a futures market on cash price variability can depend on whether the data are daily, weekly, or monthly.

This paper presents a theoretical model with comparative statics which is then tested empirically to determine the effects of the live cattle futures market on the distribution of daily cash prices and the speed of cash price adjustments. This paper goes beyond past research by examining daily prices, rather than weekly or monthly. It focuses on the effect of the futures market on the standard deviation and first-order autocorrelation of daily cash prices. The results of both the theoretical and empirical models support the hypothesis that the existence of the live cattle futures market is coincident with increased short run price volatility and improved cash market efficiency.

The results may help explain why cattle producers have perceived futures markets as increasing volatility, while past research that used weekly or monthly prices tends to suggest that futures markets have decreased cash price volatility.

Theoretical Model

The efficient markets hypothesis (Fama, 1970; Samuelson, 1965) suggests that prices in perfectly competitive markets should be statistically indistinguishable from a random walk or martingale process. Danthine (1970) and Lucas (1978) argued this was only true if (1) there are no transactions costs, (2) all traders are risk neutral, (3) information is transmitted to all traders instantaneously, (4) all traders agree about the influence of new information on current prices, and (5) the cost of information is zero for all traders. These assumptions are questionable for futures markets, and they are certainly inappropriate for commodity markets where transaction costs (e.g., transportation and storage) are high.

Because of seasonal costs of production, cattle prices would still be seasonal even in an efficient market. It is seasonally adjusted cattle prices that Samuelson would argue should follow a random walk. Empirical research has consistently rejected the random walk model even for seasonally adjusted cash commodity prices (e.g., Bailey and Brorsen, 1985). Disequilibrium models may be appropriate in analyzing short run price movements in cash markets (e.g., Black, 1976; Beja and Goldman, 1980). The equilibrium assumption of past theoretical work is likely not appropriate for daily prices. Disequilibrium could exist in the short run because of "friction" due to transaction costs, taxes, information costs, asymmetric information, and the inability of traders to determine instantaneously the impact of a new piece of information. Differences in information for various buyers and sellers may be large. Transaction costs such as transportation and shrinkage are substantial for live cattle. Friction due to transaction costs may cause cash cattle prices to adjust slowly and thus price changes might exhibit the positive autocorrelation found in empirical studies.

Thus, we could reasonably represent the movement of seasonally adjusted cash prices as a partial adjustment process:[3]

(1) $P_t^* = \gamma + P_{t-1}^* + \mu_t$, and

(2) $\Delta P_t = P_t - P_{t-1} = \gamma + b(P_t^* - P_{t-1})$

where P_t^* is the equilibrium seasonally adjusted price in time t, P_t is the actual seasonally adjusted price in time t, b is a constant between 0 and 1, γ is a constant, and μ_t is a zero mean, uncorrelated error term with constant variance, but is not necessarily normally distributed. To conform with the subsequent empirical section the prices are measured in terms of natural logarithms. Equation (1) is defined more generally as a random walk with drift. If there are no trends, then γ equals zero.

Futures markets should experience less friction than cash markets because of substantially lower transaction costs. Thus futures prices are expected to have less autocorrelation than cash markets.[4] However, cash prices are expected to move in parallel with futures prices either through arbitrage or formula pricing. Research on live cattle (Oellermann and Farris, 1985; Purcell and Hudson, 1985; Koontz, et al., 1987) and other commodities (e.g., Garbade and Silber, 1983; Ng, 1987; Kawaller, et al., 1987) shows that futures market prices lead cash prices, suggesting the futures market is the center for price discovery. Given this evidence that cash prices move with futures prices, it follows that cash prices should have lower autocorrelation in the presence of an actively traded futures market. This implies that b in equation (2) would be larger in the presence of a futures market. By speeding price adjustments, the futures market can improve the efficiency of cash markets by reducing the time needed for information to be reflected in prices.

Even with the futures market there are still reasons to expect disequilibrium and thus b will likely still be less than one.

By repeated substitution in equations (1) and (2), we can show that

$$(3)\quad \Delta P_t = \gamma + \sum_{i=0}^{\infty} b(1-b)^i \mu_{t-i}.$$

The variance of price changes is

$$(4)\quad Var(\Delta P_t) = \sum_{i=0}^{\infty} [b(1-b)^i]^2\, Var(\mu_t).$$

From equation (4) we can see that the variance of price changes increases as b increases:

$$(5)\quad \partial\, Var(\Delta P_t)/\partial b = 2\, Var(\mu_t) \sum_{i=0}^{\infty} [b(1-b)^i][(1-b)^i + ib(1-b)^{i-1}] > 0$$

since $0 < b < 1$. This implies that we should expect the variance of price changes to increase in the presence of the futures market.

Prices likely fully adjust in a week or a month and thus this theoretical model suggests little or no effect of futures markets on weekly or monthly measures of volatility like those examined in most past research. Therefore, $Var(\mu_t)$ can be estimated as the variance of monthly or weekly price changes.

Multiplying equation (3) by (1 - bL), where L is the lag operator, we get

$$(6)\quad \Delta P_t = \gamma + (1 - b)\, \Delta P_{t-1} + b\, \mu_t.$$

Equation (6) is a first-order autoregressive model and therefore the estimate of (1 - b) is the first-order autocorrelation coefficient.[5] From equation (4):

$$(7)\quad SD(\Delta P_t) = SD(\mu_t)\, f_1(b)$$

where SD denotes the standard deviation and

$$f_1(b) = (\sum_{i=0}^{\infty} [b(1 - b)^i]^2)^{1/2}.$$

Next, assume that the speed of price adjustment as measured by b (or 1 - b) is affected by a set of factors, X, which contains $SD(\mu_t)$ as well as the existence of futures markets. Thus,

$$(8)\quad b = f_2(X)$$

and by substituting equation (8) into equation (7):

$$(9) \quad SD(\Delta P_t) = f_3(X).$$

Equations (8) and (9) are specified linearly and used to specify the empirical model in the next section.

Empirical Model

The period of 1957 through 1982 was selected for this analysis, so that the entire period studied by Taylor and Leuthold (1957-72) and ten subsequent years could be included. Therefore, eight years prior to the introduction of futures trading in live cattle and eighteen years subsequent to it are included in the analysis. Following past research, statistics of interest were calculated for each year. This provides enough observations to obtain accurate estimates of the variance of monthly price changes.

The data used for the daily cash prices were obtained from the Dunn and Hargitt Commodity Data Bank and the USDA Market News Office in Omaha, Nebraska. The average daily cash prices of 1100- to 1300-lb. choice steers in Omaha were used as the cash price series. All prices were transformed to their natural logarithms and the data were first-differenced (logarithmic price changes can be interpreted as percentage changes in continuous time). Differencing removes any linear trend component and greatly reduces the effects of any long-term cycles. The measure of variability used is similar to Powers who also used differences. In contrast, Taylor and Leuthold measured variability as the variability of prices about the mean price. Tomek (1979-80) defined variability as the variation in prices that could not be explained by a regression model.

The Omaha market was selected because it served as a focal cash market for slaughter cattle throughout the period of analysis. It has been a delivery point for the live cattle futures contract since its inception and has been a par-delivery point since 1971.

The volume of cattle marketed on the Omaha cash market declined significantly during the period of analysis, generally in proportion to the decline in total marketings at major U.S. cattle terminals during 1957-82. The Omaha cash price was widely quoted throughout the period.

The decline in market volume, to the extent that it contributed to market thinness, could have made the Omaha cash price more susceptible to influence by such an outside force as futures trading (Hayenga, 1978). However, observers of the Omaha market note that the market maintained a competitive structure throughout the 1957-82 period (Phillips, 1986). The data period ends in 1982, since concentration has increased in recent years.

The Omaha market is typically not active the last two days of the week. Thus, we follow Oellermann and Farris (1985) and only consider price changes on Monday, Tuesday, and Wednesday. Seasonality was removed from the data via the following regression equation:

$$(10)\quad p_t - p_{t-1} = \alpha_0 + \alpha_1 \sin(2\pi n/252) + \alpha_2 \cos(2\pi n/252) + \alpha_3 \sin(2\pi n/126) + \alpha_4 \cos(2\pi n/126)$$

where p_t is the logarithm of the actual price in time t and n is the cumulative number of business days in the year. The regression was run using only the Monday, Tuesday, and Wednesday price changes. The regression was statistically significant ($p = .008$), but the R^2 was only .005. the seasonally adjusted data are the residuals from equation (10). We also tested the null hypothesis that seasonality was the same across the four time periods of this study. This null hypothesis was not rejected (calculated $F = 1.30$ critical $F_{\alpha=.10} = 1.49$). Contrary to what past research suggested, seasonality was slightly stronger when the futures market was trading.

The standard deviation for each year is then the standard deviation of the residuals of (10). The autocorrelation is then calculated as the correlation between Monday and Tuesday and Tuesday and Wednesday seasonally adjusted price changes.

To examine the impact of the live cattle futures market on cash price variability and volatility, the following ordinary least-squares model was used. Unlike past research on live cattle, this model is formulated to correct for factors other than the presence of futures trading that may have influenced changes in the distribution of cash prices over time.

(11) $M_t = a_0 + a_1R_t + a_2I_t + a_3D_1 + a_4D_2 + a_5D_3 + e_t$, t = 1956, 1982

where: M_t = standard deviation or first-order autocorrelation of seasonally adjusted daily log changes in Omaha cash prices for slaughter cattle during year t.

R_t = standard deviation of the log of monthly seasonally adjusted price changes during the year.

I_t = yearly change in general price level as measured by percentage change in GNP implicit price deflator (Source: U.S. Department of Commerce).

D_1 = 1 for years 1965 through 1972, 0 otherwise.

D_2 = 1 for years 1973 through 1977, 0 otherwise.

D_3 = 1 for years 1978 through 1982, 0 otherwise.

Table 1 shows the data used in the regressions.

The variable R_t is included as the estimate of $SD(\mu_t)$. Peck (1981) used a similar measure to capture the influence of new information in a study of the effects of speculation on futures markets. The null hypothesis of no autocorrelation in the monthly price changes using the test proposed by Ljung and Box (1978) could not be rejected. Thus, this variable seems to be a reasonable measure of $SD(\mu_t)$.[6] As supply and demand conditions for cattle change more during a given year, R_t increases and is expected to lead to an increase in cash price variability.

The general price change variable I_t is included to account for macroeconomic conditions.[7] General price inflation may impair the speed of price adjustment in the cattle market, leading to decreased standard deviation and

Table 1. Yearly Standard Deviation and First-Order Autocorrelation of Daily Logarithmic Changes in Cash Price of Live Cattle at Omaha, Nebraska; Monthly Standard Deviation; and Percentage Change in GNP Implicit Price Deflator, 1957-82.

Year	Standard Deviation (%)	First-Order Autocorrelation	Monthly Standard Deviation (%)	Inflation Rate (%)
1957	1.020	0.309	3.772	3.41
1958	0.764	0.284	4.259	1.71
1959	0.768	0.060	2.598	2.36
1960	0.841	0.240	3.566	1.63
1961	0.814	0.317	4.240	0.92
1962	0.952	0.169	4.613	1.85
1963	1.032	0.296	5.022	1.50
1964	1.428	0.095	5.718	1.53
1965	0.891	0.050	3.427	2.19
1966	1.100	-0.001	5.660	3.23
1967	0.917	0.002	2.640	3.00
1968	0.746	0.010	3.586	4.40
1969	0.968	0.145	4.241	5.15
1970	0.953	0.055	3.132	5.37
1971	0.770	0.189	3.209	4.99
1972	1.065	0.322	4.070	4.16
1973	1.639	0.135	8.340	5.75
1974	2.209	-0.007	10.434	8.82
1975	1.564	0.346	8.578	9.31
1976	1.967	-0.231	8.148	5.21
1977	1.157	-0.091	5.332	5.83
1978	1.357	0.092	4.072	7.40
1979	1.462	0.426	7.503	8.64
1980	1.271	-0.020	4.368	9.18
1981	1.146	0.035	4.500	9.63
1982	1.242	0.097	5.344	6.02

increased first-order autocorrelation. Carlton (1983) used a similar variable in a study of futures market trading volumes based on similar arguments.

The three dummy variables are included to test for differences in the dependent variable between the 1957-64 pre-futures period and three relatively distinct periods of futures trading in live cattle since 1964. Positive (negative) signs on the dummy variable coefficients (a_3, a_4, and a_5) will indicate that the dependent variable increased (decreased) during each period, relative to the level observed before futures trading began. But, as with any regression model, the model can not prove causality. It can only show correlation. Indeed, the hypothesized effects of the futures market developed in the theoretical model would be the same for any innovation that improved market efficiency.

The first period selected (1965-72) corresponds to the eight years considered by Taylor and Leuthold. The remaining 10 years were divided into two five year periods (1973-77 and 1978-82). The effects of the futures market are expected to vary depending on the usage of the futures market and price variability. We expect the effects of the futures market to be small when the futures market is not used as the primary point of price discovery. This appears to be the case in the early years of the futures market, when open interest as a proportion of U.S. slaughter was very low, increasing gradually until 1972. In 1973, the open interest to slaughter ratio increased 25% to a record high and has continued to increase since then.

By taking the derivative of equation (5) with respect to var(μ_t), we can see that the effects of the futures market on the cash market would be greater during periods of high price variability. Also, during periods of rapidly moving prices, we might expect cash market participants to watch the futures market more closely. The monthly standard deviation during the three periods averaged 4.12, 8.17, and 5.16. Therefore, the effects of the futures market could be greatest during the 1973-77 period.

Empirical Results

The regression results are presented in Table 2. The monthly standard deviation and inflation variables were statistically significant in all but one case. Thus, our model is an improvement over past research since it does account for other significant factors which affect the distribution of price changes. Increases in either inflation or monthly price variability led to markets being slower to adjust as expected. The coefficient on the monthly standard deviation in the daily standard deviation equation is positive. This is the relationship suggested by equation (4).

The R^2 value for the autocorrelation equation is much lower than for the standard deviation equation. This is due to differences in the accuracy of estimating the dependent variable. The standard deviation is based on about 150 observations per year which is plenty to give a quite accurate estimate. The autocorrelation estimate is based on about 100 observations per year. The standard deviation of each autocorrelation estimate is approximately $1/\sqrt{T}$, where T is the number of observations. Thus, they have a standard deviation of about 0.1 which explains the low R^2.

Each of the dummy variables representing the existence of the futures market is significant and has the expected sign. The 1965-72 period dummy variables had the smallest coefficients. Open interest was low during this period and thus it is not surprising to find less correlation between the existence of the futures market and the cash price statistics. The 1973-77 and 1978-82 periods both show larger effects.[8]

These results show that simultaneous with the introduction of the futures market, autocorrelation decreased and the standard deviation increased. Thus, market efficiency in the sense of Fama increased in the presence of the futures market, but short-term price risk also increased.

Table 2. Estimated Regression Coefficients for Live Cattle Cash Price Statistics.[a]

	Autocorrelation	Standard Deviation (%)
Intercept	-0.017	0.337*[b]
	(-0.17)	4.29)
Monthly Standard Deviation (%)	0.04055*	0.1457**
	(1.82)	(8.28)
Inflation (%/1000)	0.377*	-0.0885
	(1.82)	(-0.54)
Dummy (1965-72)	-0.186**	0.081*
	(-2.57)	(1.47)
Dummy (1973-77)	-0.545**	0.271**
	(-3.80)	(2.44)
Dummy (1978-82)	-0.377**	0.267**
	(-2.58)	(2.33)
R^2	0.44	0.93
No. Observations	26	26

[a] Estimates were obtained using a correction for autocorrelation in the residuals using the Yule-Walker estimation option for PROC AUTOREG in SAS/ETS (SAS Institute, Inc., 1984).

[b] One and two asterisks denote statistical significance at the 10 and 5 percent levels using a one-tailed test for the dummy variables.

Concluding Comments

This paper presented both theoretical and empirical models which suggest that, in the presence of a successful futures market, cash market efficiency improves, but short run cash price risk increases. Past research suggesting that futures markets may reduce long run price variability by improving intertemporal allocation of supply is convincing. But our results can explain why futures markets are perceived negatively while this past research cannot.

Cattle producers apparently perceive futures markets as destabilizing cash markets. Our empirical results show that after futures trading began, short run price risk increased, consistent with theoretical expectations. While our dummy variable model certainly may not have captured influences of some other factors, the results are consistent with perceptions of cattle producers. The paper also argues that any increase in volatility exists only in the very short-run.

The following question thus arises: Does the disadvantage of increased short run price risk outweigh the advantages of improved intertemporal allocation of supply, lower long run price variability, improved market efficiency, and reduced risk to users of futures markets? We certainly think not, and therefore we believe that banning trading in live cattle futures would be a serious mistake. But, we believe our finding that futures markets increase short-run price variability is important for understanding why cattle producers perceive the futures market as adversely affecting cash prices.

Footnotes

[1] See Britto (1985) for a more extensive review of literature on the effects of futures markets on cash prices.

[2] Whittaker, et al. (1988) did use daily data in their study of the effects of futures trading on the municipal bond market. They included two variables to represent the futures market (a dummy and futures market open interest) and the coefficients for the variables had opposite signs. But, assuming open interest was 10,000 contracts during their observation period, the positive effect dominates the negative for both of their models. Thus, their results offer support for our argument that short-term volatility increases in the presence of the futures market.

[3] The mathematical model presented here is an extension of one developed by Chance (1987). Chance considered only a single shock to the model $P_t = P_{t-1} + b\mu_t$. Chance reached the same conclusion that we do, that variance increases in the presence of a futures market. Also, note that this model defines the univariate probability distribution function.

[4] The work of Irwin and Uhrig (1984) and Taylor (1986) suggests that even futures prices exhibit slight autocorrelation.

[5] Tomek (1979-80) defined variability as the residuals of equation (6). The variance of the residuals is $b^2 \, var(\mu_t)$. The derivative with respect to b is $2b \, var(\mu_t)$ which is greater than zero. This implies that variability as defined by Tomek should also increase in the presence of a futures market. Tomek argued the opposite, but his footnote 1 on page 353 acknowledges in regard to Cox's paper, "The model, as published, apparently contains an erroneous derivation (private communication from Cox). In the corrected result, the theoretical model implies that an increase in information (say, from a futures market) increases the variance of the error term." Thus, our theoretical model is consistent with Cox's corrected model. Tomek found that variability did indeed increase in the presence of the futures market.

But, he argued that if he dropped 1973 then variability only increased slightly for live cattle and the variability in the two periods could be considered approximately equal.

[6] As estimated, it is specifically a measure of $\sqrt{N}\ SD(\mu_t)$ where N is the number of market days in a month.

[7] Money supply and interest rates are possible alternatives. Each was substituted for inflation, but neither was significant in either equation.

[8] Tomek (1979-80) argued 1973 was an outlier due to price controls and dropped it from his calculations. The method of Belsley, Kuh, and Welsch (1980) shows that 1973 is not an influential data point for the models estimated here.

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