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ABSTRACT

A new interpretation of commodity futures price theory is evaluated because, currently, many products exhibit price behavior which cannot be explained with existing theory. A method for classifying products according to the particular price theory relevant to them is provided. The classification method uses the futures price dependence enforced by arbitrage opportunities in spot markets as its base. The futures markets for beef cattle and corn are used as examples.

PRICE DEPENDENCE AND FUTURES PRICE THEORY

A new interpretation of existing commodity futures price theory is needed because many products traded on futures markets do not fit the description of either a perfectly storable or a perfectly non-storable commodity. This new interpretation should consider these products to be "semi-storable" in nature and should assist in determining which of the two standard price theories best explain observed price behavior.

Perfectly storable and perfectly non-storable commodity futures price theories are useful for defining the extremes of existing theory. However, what is needed now is an explanation of the price behavior of products which have some of the characteristics of both "storable" and "non-storable" products. This new interpretation would serve to explain the behavior of markets which fall between the two extremes.

Objectives and Literature Review

The objectives of this paper are to specify a simple method for classifying products according to which theory best explains their price behavior and to discuss possible sources of price dependence. Both live and feeder cattle will be used as examples because of the relatively large amount of futures price data available compared to other products not considered to be "storable" and due to the maturity of the two markets. Corn will be analyzed also, as an example of storable product price performance.

In the past, theories regarding futures prices dealt with price dependence over time. Unfortunately, the names of the theories and their applicability to particular products have been based on a product's storability. This is due, in the most part, to the fact that storability was considered to be a necessary characteristic of a product to be traded on a futures market (Skadberg and Futrell). The successful introduction of live cattle futures contract forced analysts to develop a theory for products which were not "storable" in

the classic sense. The resulting literature examined the implications of non-storability on pricing behavior. However, factors other than the storability of a commodity are likely to be important in explaining the pricing performance of futures markets. Factors such as size of annual production variations, government intervention, quality of information and market efficiency have been identified as having a significant impact on prices in studies typified by Kofi, Leuthold (1974), Cox, Goss, and Koppenhaver.

Therefore, this paper will use a broader definition of "storable." Here "storable" will be defined as "flexible production and marketing options." In other words, a product considered to be storable is one which allows producers to vary the production and/or marketing process so as to vary market supplies over time.

The need for clarity in existing price theory, especially that related to products considered to be perfectly non-storable commodities, is illustrated by the number of studies which have found fault with applying either extreme theory to particular products. As early as 1967, Paul and Wesson found that feeder and live cattle futures were sufficiently related to allow them to be used to determine a market value of feedlot (transformation) services. Ehrich found that the average spread between cash and futures prices tended to equal feeding costs plus a competitive profit. Later studies by Leuthold (1974, 1977), Erickson, Pyne, and others have continued to find relationships between cash and futures prices. Such behavior is typical of markets for storable commodities where current cash and distant futures prices are expected to be strongly related; theory says that there is one price--the cash price--within each market area and that all other prices are related to that one price by the cost of storage over time (Jain). According to theory for perfectly non-storable products, no relationship should exist between cash and futures prices, or between prices for different futures contracts (Leuthold 1977; Skadberg and Futrell; Tomek and Robinson; Tomek and Gray).

The fact that some relationships have been found to exist implies that cattle is not a perfectly non-storable product or that storability alone does not determine market price dependence over time. Both of these implications will be considered here.

Lack of depth in our understanding of futures markets for commodities which are not perfectly storable has limited the practical uses and interpretations of these markets. For example, Ehrich found that a large segment of the U.S. cattle feeding industry probably viewed current and past cash prices as the best available indication of expected prices. This observation received some support from Leuthold (1974) who found that "from about 15 to 36 weeks prior to delivery, one can expect a better estimate of the future cash price of cattle by looking at the present cash price than by studying the futures price itself." But Miller and Kenyon found that fed cattle futures prices had been used as expected output prices by numerous fed cattle producers, and this had affected feeder cattle prices.

Futures markets for products which are not storable are thought to be "forward-pricing" (hedging) markets only (Skadberg and Futrell). However, Miller and Kenyon's evidence indicates that a great number of cattle producers have used the cattle futures market as a forecasting market. Therefore, it appears that some cattlemen and other users of beef cattle futures markets are unsure of which function(s) the markets perform efficiently (if any)--a pricing (forecasting) function and/or a hedging function.[1] Empirical studies add to the confusion: Studies by Barton and Tomek and by Leuthold (1983) found widespread use of the markets by hedgers attracted by the numerous opportunities for increasing profits, which were identified by Hayenga and DiPietre and Hayenga et al. However, Koppenhaver found that a risk premium existed when using routine hedging. As for forecasting, Martin and Garcia concluded that the live cattle futures market had not performed the forecasting

function well, yet Just and Rausser found the market to be about as accurate as were large econometric forecasting models. Also, Kolb and Gay found that cattle futures markets perform the price discovery process without significant bias in prices. Despite confusing empirical results, it is clear that if cattle futures markets perform a valid forecasting function, the products cannot be considered perfectly non-storable in nature. This lack of independence would imply some relationship between prices which are supposed to be completely independent.

The Classification Method

A method is needed which will assist futures traders and analysts in identifying whether a product's futures market price behavior is better explained by the theory existing for either perfectly storable or perfectly non-storable commodities. It is expected that virtually no product will perform exactly as predicted by the extreme theories, but it is likely that each product will fall closer to one end of the continuum than the other. Therefore, in this section a method is proposed which will provide quantitative information for use in the process of identifying the appropriate theory for a product.

Two major propositions concerning prices of semi-storable commodities can be derived from the empirical results. First, all prices will be related due to producers' tendency to use current cash and distant futures prices in their production planning. Second, factors such as the marketing flexibility of a commodity affect the accuracy of the pricing function that its futures market performs due to the relative ease of making forecasts (within a crop year) for storable products, as compared to non-storables. The strength of the relationship between prices depends on the ease with which market inventories can be altered over time, space, and product form. Whereas storable product inventories can be altered very easily and non-storable product inventories

cannot be altered at all in the short run, semi-storable products will have some of the characteristics of both storable and non-storable commodities. Semi-storable products will have some flexibility in their market inventories in the short run, like storables, but that flexibility will be limited by the same production and marketing problems faced by non-storables. Therefore, the level of "storability" of a product affects arbitrage opportunities - the more flexible a product, the more opportunities for arbitrage over time and space. The efficiency of the arbitrage process, in turn, enforces price dependence. Inventories being stored create price dependence over time, while spatial price dependence is created when inventories can be transported during the storage period. Price dependence can also appear to exist in non-storable product futures markets in the short run when supply (production) and demand factors are temporarily stable, even though no price relationship actually exists.

The two propositions concerning prices of semi-storable commodities described above are at least implied in part in previous studies (Tomek and Gray; Miller and Kenyon; Leuthold and Tomek; Kofi; Leuthold 1974). The first proposition is supported by Leuthold and Tomek, for example, who write, "Expectations about future economic conditions can influence current cash prices as well as future prices...." Tomek and Gray support the second proposition when they write, "The corn and soybean markets provide greater certainty in forecasting in the future (than the potato market)." Kofi came to similar conclusions for the same products.

The extremes of commodity futures price theory can be expressed quantitatively. The theories of perfectly storable and perfectly non-storable commodities, respectively, expect price relationships such that:

(1) $r(CP_t, FP_{t+i}*) = r(FP_t*, FP_{t+i}*) = r(CP_t, CP_{t-i}) = 1 > r(CP_t, FP_t^{t-i})$

(2) $r(CP_t, FP_{t+i}*) = r(FP_t*, FP_{t+i}*) = r(CP_t, CP_{t-i}) = 0 < r(CP_t, FP_t^{t-i})$

where

r is the coefficient of correlation between the variables,

CP_t is the cash price at time t,

CP_{t-i} is the cash price at time t minus i,

FP_t* is the current futures price for a contract maturing at time t,

$FP_{t+i}*$ is the current futures price for a contract maturing at time t plus i, and

FP_t^{t-i} is the futures price at time t minus i for a contract maturing at time t.

    Expression 1 states that there is perfect correlation between cash and futures prices over time with only one exception: a basis relationship must narrow. This indicates that perfectly storable commodities will always have a full carrying charge market within crop years. Expression 1 is supported by Tomek and Gray who write, "...in circumstances involving continuous inventories, forecasts are reflected just as much in cash and nearby futures as distant futures prices. The element of expectations is imparted to the whole temporal constellation of price quotations, and futures prices reflect essentially no prophecy that is not reflected in the cash price and is in that sense already fulfilled" (p. 373). Expression 2 states that the only correlation between cash or futures prices of perfect non-storables is between futures contract prices and the cash price at the contract maturity date.[2] The clear implication of these two expressions is that the more "storable" a product is perceived to be by traders, the more the correlation in the prices of that commodity, ceteris paribus.

    Expressions 3 and 4 attempt to specify more realistic price relationships for semi-storable product markets.

(3) $1 > r(CP_t, FP_{t+i}*) > r(FP_t*, FP_{t+i}*) > 0$

(4) $1 > r(CP_t, FP_t^{t-i}) > r(CP_t, CP_{t-i}) > 0$

Expression 3 states that the correlation between current cash and futures prices is greater than the correlation between two futures contracts, and both correlations are between one and zero. The correlation for $(CP_t, FP_{t+i}*)$ should exceed the correlation for $(FP_t*, FP_{t+i}*)$ because it is expected that all futures contract prices are affected by cash prices, but the amount of the adjustments made by traders in their expectations for different futures contracts will vary, depending on the supply situations expected to exist at each contract maturity date (Hieronymus). Expression 4 states that the correlation between cash and futures prices is greater than the correlation between cash prices at two different points in time, and both are between one and zero.

To test whether, in fact, all prices are related for a particular product, the existence of a significant relationship between combinations of both cash and futures prices for live cattle, feeder cattle, and corn are considered. In each case, simple regression analysis is used to determine the degree of correlation between the sets of price data. The data used are disaggregated weekly average prices for each live cattle futures contract to mature from the beginning of April 1968 to the end of February 1984 and similar data for each feeder cattle futures contract to expire from the beginning of May 1972 to the end of March 1984 and each corn contract to mature from the beginning of May 1968 to the end of March 1984. Cash price data came from Omaha cattle and Chicago corn markets. Time lags ranging from one to eight months are used to provide greater insight into the significance of the results.

Futures prices for corn and both live and feeder cattle are compared with cash prices from their respective markets to determine the degree of pricing accuracy. The ability of futures markets to accurately estimate distant cash prices is tested using least-squares analysis with the simple model:

(5) $CP_t = a + bFP_{t-i}$

where CP_t is the cash price at delivery and FP_{t-i} reflects the futures price during the i-th month before maturity. In these models[3] if FP_{t-i} is an accurate forecast of CP_t, there will be a significant relationship between the two price series.

Empirical Results and Analysis of Price Dependence

To test whether there is a significant relationship between current cash and futures prices of beef cattle, Pearsonian correlation coefficients are computed. The results of these calculations are presented in Table 1. The general hypothesis of independence between cash and futures price movements is analyzed, considering time lags from one to eight months for corn and live cattle and from one to five months for feeder cattle.

With inspection of Table 1, it is clear that the general hypothesis of independence between current cash and current futures prices of beef cattle is rejected for all time lags considered. All the correlation coefficients, R, are high and all the associated F-test scores are statistically significant at the 5 per cent confidence level. In fact, there is little difference between the scores for corn and cattle.

The results presented in Table 1 support the conclusion that traders in a semi-storable commodity futures market base their expectations of later prices on current price behavior. Using current price information when forming forecasts of market prices appears to be a logical approach to futures price analysis, but it contradicts the expected outcome for perfectly non-storable commodity markets.

The existence of correlation between cash and futures prices of beef cattle leads to the expectation that futures prices of individual cattle contracts may be correlated also. It has long been hypothesized that no such correlation should exist; it is believed that prices of individual futures contracts for a non-storable commodity should be independent of one another

TABLE 1: RELATIONSHIPS BETWEEN CURRENT CASH AND CURRENT FUTURES PRICES
$(r(CP_t, FP_{t+i}*))$

Futures contracts to mature in -	Live cattle correlation (R)	Feeder cattle (R)	Corn (R)
1 month	.958	.961	.975
2 months	.921	.957	.960
3 months	.867	.933	.951
4 months	.859	.923	.943
5 months	.831	.899	.936
6 months	.852	--	.892
7 months	.831	--	.876
8 months	.856	--	.849

(Leuthold 1977; Skadberg and Futrell; Tomek and Robinson). Table 2 provides the resulting correlations when all corn and live cattle contracts with delivery dates two, four, six, and eight months apart are compared. Table 2 also presents the results of similar analysis of all feeder cattle contracts with maturity dates one, two, three, and four months apart.

The major conclusion drawn from these results is that the hypothesis of independence between prices of individual cattle futures contracts is rejected overall. The hypothesis could be rejected for contract combinations with delivery dates two, four and six months apart, but might not be rejected for contracts maturing eight months apart.

It appears that U.S. cattle feeders, as hedgers in the live cattle futures market, play a major role in creating price dependence between contracts. It is noted that most fed cattle are in the feedlot six months or less. Therefore, the longest period of time that a cattle feeder might hold a hedge in the futures market would be about six months.[4] It is this factor which ties together contracts with delivery dates six months apart or less. A cattleman considering the purchase of some number of feeder cattle to place on feed during a particular month in the near future uses current cash and futures prices of live cattle as a guide or estimate of the national price for fattened cattle. If the price is high enough to encourage the cattle feeder to place the hedge, his futures market activity in the distant delivery month live cattle contract will be related to the price of nearby contracts. This conclusion supports the position of Feder, Just, and Schmitz concerning futures markets and their influence on a firm's production decisions.

It is also observed that the degree of price dependence between individual live cattle futures contracts decreases as the amount of time between contract maturity dates increases. This is illustrated by the gradually increasing number of insignificant scores in Table 2. The explanation for this phenomenon,

TABLE 2: RELATIONSHIPS BETWEEN FUTURES CONTRACTS $(r(FP_t^*, FP_{t+i}^*))$

Time lag in months	Correlation Scores			Insignificant scores
	Hi	Low	Median	
Live cattle (a)				
2	.995	.273	.851	0
4	.991	.044	.741	3
6	.992	.009	.670	9
8	.989	.004	.687	23
Feeder cattle (b)				
1	.996	.445	.910	0
2	.991	.830	.931	0
3	.980	.451	.906	0
4	.988	.172	.913	2
Corn (c)				
2	.998	.504	.946	0
4	.994	.517	.929	0
6	.990	.500	.925	0
8	.990	.427	.920	0

(a) Ninety-six contacts maturing from 1 April 1968 to 28 February 1984.
(b) Eighty-four contracts maturing from 1 May 1972 to 31 March 1984.
(c) Eighty contracts maturing from 1 May 1968 to 31 March 1984.

like the other just discussed, is based on the behavior of hedgers in the market.

It appears that the level of price dependence may be inversely related to the opportunity for change in the number of cattle marketed during a period of time. For contracts maturing two and four months apart, the statistical significance of the individual scores is very high as there is little opportunity for cattle feeders to change their production process enough to alter market supplies greatly during the time between delivery dates. With a six-month lag, however, the level of statistical significance decreases and there are many more insignificant scores. This trend is even more pronounced with an eight-month lag. The rapid deterioration in the level of price dependence between contracts maturing six and eight months apart, compared to that for contracts maturing two and four months apart, appears to be influenced greatly by the increased opportunities for cattle feeders to alter the supplies of beef cattle marketed during a given period. The cattle feeding process averages 100-120 days in length, approximately 3 1/2 to 4 months, but it is much easier to lengthen that process than it is to shorten it to any great extent. Even so, 180 days (six months) is approximately the longest period of time that cattle can remain on feed profitably. Therefore, when considering delivery six or eight months apart (or longer) there are clearly two feeding periods involved, providing a wider range of choices for cattle feeders.

Empirical Results and Analysis of Price Accuracy

The second proposition being tested states that the pricing function of a futures market for a storable product will be more accurate than that of a non-storable product and storable product price forecasts are more easily made. In other words, current futures prices and cash prices at the distant maturity dates of those contracts will be related for all commodities. The difference in forecasting ease is due in part to the fact that for a perfectly

storable product there is only one production and marketing period to be considered by a futures trader in forming a price estimate. Therefore, it is possible that there will be much more data available concerning market supplies of a storable product than information concerning a non-storable product, leading to more accurate forecasts for storable products. For a perfectly non-storable product there may be a number of supply periods to be considered (Paul, Kahl and Tomek).

The results presented in Table 3 indicate the level of pricing accuracy of live cattle, feeder cattle, and corn futures markets as measured using the simple model in equation 5. The general observation which can be made about the results presented[5] is that the futures markets appear to do a more accurate job of pricing for shorter time lag periods.

The new empirical results for live cattle and corn presented in this study agree with those of Leuthold's 1974 study while extending similar analysis to feeder cattle. The level of correlation for feeder cattle is nearly identical to that for both live cattle and corn for the various time lags although corn is slightly higher. This indicates that the feeder cattle futures market performs its forecasting function as accurately as do those of both the other products. Apparently the quantity and/or quality of data available is similar for these markets. These results make it difficult to accept the proposition that storable products have more accurate futures markets than do non-storables. The results in Table 3 appear to indicate that all three products tested perform a forecasting function with decreasing accuracy over increasingly longer time periods, meaning that all three might be considered "semi-storable" in this regard.

The results presented in Table 4 indicate the decreasing degree of accuracy that current cash prices have in forecasting distant cash prices. Clearly, current cash prices will be an accurate predictor only if price levels do not change. If information related to supply and/or demand factors changes over

TABLE 3:   PRICING ACCURACY OF THE FUTURES MARKETS(a) $(r(CP_t, FP_t^{t-i}))$

Months prior to delivery	Live cattle (R)	Feeder cattle (R)	Corn (R)
1	.93	.93	.96
2	.80	.83	.88
3	.79	.81	.83
4	.74	.70	.82
5	.73	.65	.79
6	.66	--	.70
7	.55	--	.65
8	.50	--	.58

(a) Eighty-four feeder cattle contracts maturing from 1 May 1972 to 31 March 1984, ninety-six live cattle contracts maturing from 1 April 1968 to 28 February 1984, and eighty corn contracts maturing from 1 May 1968 to 31 March 1984.

TABLE 4: CORRELATION BETWEEN CASH PRICES $(r(CP_t, CP_{t-i}))$

Time lag in months	Live cattle (R)	Feeder cattle (R)	Corn (R)
1	.90	.91	.95
2	.82	.84	.88
3	.59	.64	.72
4	.47	.57	.60
5	.38	.39	.42
6	.25	--	.39
7	.24	--	.12
8	.17	--	.11

time, prices must change. The longer the time period being considered, the more opportunity there will be for price level changes.

Conclusions

It appears that feeder cattle futures price behavior is slightly more "storable" than that of live cattle, although both can be classified as "semi-storable" commodities in regards to their marketing characteristics. There is some correlation in the price series for both products, but in most cases the amount of correlation in feeder cattle prices is greater than that for live cattle and less than that for corn. The empirical evidence presented in Tables 1-4 support expressions 3 and 4, which describe semi-storable commodity futures price relationships. In all cases, the correlations between current cash and futures prices exceed those between futures contracts for each cattle product,[6] as described in equation 3. All correlations between cash and futures prices exceed those between cash prices, as described in equation 4. As discussed earlier, a major source of correlation in the prices of any commodity is the degree of flexibility available in the production and marketing processes for that product. It was noted that producers of live cattle, feeder cattle and corn all have the ability to vary market supplies somewhat over time. It was also found that all three futures markets performed their forecasting function with similar degrees of accuracy.

These conclusions indicate that traders in feeder cattle futures should expect price behavior with slightly more "storable" characteristics than should live cattle traders. Therefore, feeder cattle traders can rely more on the well-documented price theory for perfectly storable commodities, while live cattle traders must use more of the relatively untested commodity futures price theory for perfectly non-storable products.

Implications of the Results

The underlying structure of the supply of live cattle in cash markets influences the product's price behavior in the futures market. The inability of cattlemen to vary the quantity of their production widely once cattle are on feed indicates that the supply function for a marketing period will be inelastic. In particular, the supply of a given feedlot at a given point in space will be extremely inelastic, implying that significant short-run price movements will result from "small" changes in demand.

Futures prices of feeder and live cattle are aggregates; they represent a national price. Although both commodities are traded on a futures exchange located in Chicago, the contracts specify several par delivery points which are widely dispersed geographically. Therefore, futures prices are derived from traders' expectations of aggregate demand and supply for a specific time in the future, but not for any particular par delivery point. An individual hedger, however, does consider a futures price as reflecting the price available at a specific place - the delivery point at which the hedger could minimize delivery costs.

Adjustments made in cattle futures prices are influenced by the fact that the price of any available futures contract is guided into a national price structure by arbitrage. In the national market provided by futures trading, arbitrage is always possible when the relevant contract is not in its delivery month. This means that the supply situation can be changed over time and space and for particular product forms (Jain).

As a future contract moves into its delivery month the opportunities for arbitrage decrease rapidly. There is less time to change the relevant supply situation through transportation or production activities. During the month, the possibility of arbitrage trading gradually transforms the futures contract into a cash contract for the delivery locations.

Within cash markets there are virtually no opportunities for arbitrage in semi-storable products over time or space and very little in product form. As a result, each cash market tends to be a separate pricing complex. This means that the available supplies in cash markets are often nearly fixed, or inelastic. Therefore, short-term changes in local demand result in widely fluctuating cash prices for the market. The national price, as indicated by futures price quotes, has little effect on the short-term supply and demand situation for a local cash market.

Suggestions for Further Research

It is suggested by the results of this study that further research is needed concerning the degree of "storability" in futures price behavior for all the new products traded on futures markets. "Storability," as it has been used in this report, is better defined as "flexibility in the production and/or marketing process." To better define our understanding of futures price relationships for semi-storable commodities, more of these products must be analyzed to provide a wider base for comparison. For each product, the center of this suggested analysis might be an effort to specify producers' ability to vary quantities marketed over time and space - in other words, to consider opportunities for arbitrage that enforce price correlation.

FOOTNOTES

1. To perform a hedging function, a futures market must simply produce prices which move in the same general <u>direction</u> as do cash prices for that product during the life of the futures contract; it is a market where basis risk is lower than price level risks. To perform a forecasting function, futures prices must indicate the price level at which the cash price will be at the futures contract maturity date. A market can perform both functions efficiently.

2. Hedgers would not use futures markets if there were no correlation between current futures prices and the cash prices received at contract maturity dates.

3. Leuthold and Tomek, and Martin and Garcia point out two problems with using a model such as the one above when testing pricing accuracy. The first problem relates to the source of errors and the need to determine whether those errors are random. In this study it is assumed that the large trading volume will serve to minimize the effects of ill-informed traders. The other major source of error, a lack of information, will also have a random effect on the markets because, as Bear showed, there is a steady flow of information through time, and cattle traders anticipate this flow properly. The second problem with using such a model is that a small sample will make interpretation of biases difficult. There is an increasingly large sample of data for cattle so this is becoming less of a problem. This study, in fact, had an available sample more than twice the size of that available to Leuthold (1974).

4. A routine hedge is one that is placed at the same time as a position is taken in the cash market and held until the cash position is liquidated. In the case of cattle feeders, a hedge would be placed at the time that cash

feeder cattle are bought and held until the fattened cattle are delivered to a buyer. This time period would range from three to six months in length. Hedgers, however, often "lift" hedges early or place several hedges during the feeding period, holding each hedge a short time only (Purcell 1977, 1978). Technically, this is speculating in the cash market.

5. In all cases the b was not significantly different from one.

6. For corn, the comparisons for six-month and eight-month lags indicated that the carrying charge relationship (Table 2) between futures contracts is stronger than that between cash and futures prices (Table 1) when different crop years may be involved.

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