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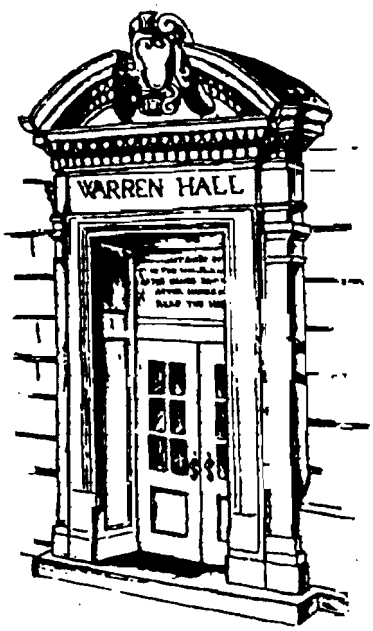

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COMMODITY FUTURES PRICES AS FORECASTS

by
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COMMODITY FUTURES PRICES AS FORECASTS

William G. Tomek

Abstract

Futures markets provide contemporaneous price quotations for a constellation of contracts, with maturities 30 or more months in the future, and a large literature exists about interpreting these prices as forecasts. It is often preferable to think of futures markets as determining a price level and price differences appropriate to the temporal definitions of the contracts. Futures prices can be efficient in reflecting a complex set of factors, but still be "poor" forecasters. Forecasts from quantitative models cannot improve upon efficient futures prices as forecasting agents; the models provide equally poor forecasts. Analogous ideas are discussed for basis forecasts.

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COMMODITY FUTURES PRICES AS FORECASTS

The discussion of prices of futures contracts as forecasts of cash prices at contract maturity goes back at least to Holbrook Working (1942), although he was reluctant to view futures prices as forecasts. Tomek and Gray attempted to elucidate and expand Working's discussion of the meaning of futures quotes as forecasts, and since the publication of their article in 1970, empirical analyses have continued, with varying interpretations of results (e.g., Kenyon, Jones, and McGuirk; Zulauf et al.). In 1986, French provided a conceptual framework for this topic (also see survey articles by Blank and by Kamara).

The proliferation of this literature suggests a need for stock-taking. Thus, an objective of this essay is to draw out implications of past research on futures markets as forecasting agencies. I also discuss issues related to forecasting bases (differences between prices), because they are associated with the idea of forecasting price levels. Discussion is limited to markets for agricultural commodities, but it is important to note that the forecasting ability of efficient markets can differ by the commodity traded.

A simple model of price level and basis behavior is outlined and used as a foundation for discussion. This model is consistent with existing literature, which derives from the work of Working (1949) for an annually produced commodity with storage, e.g., corn. I do, however, provide some observations about other commodities. I also comment on the emphasis in the current literature on econometric technique and details, which while important, tend to miss the big picture of analyses of futures prices.

A Model

In this economy, current production, S_1, is assumed predetermined by prior decisions. Emphasis is placed on the supply and demand for storage (e.g., Telser), the demand for current consumption, and an identity linking current consumption, inventory, and future consumption. The initial discussion is in terms of two periods with no production in the second period. This can be viewed as an intrayear storage model (see Williams and Wright for a good summary of the storage literature). This model can be modified so that production takes place in each of the two years with storage from one year to the next.

The simpler two-period model contains four current endogenous variables and four equations. The endogenous variables are current consumption, the quantity of inventory (consumption in period two), current quote of a futures price (for period two), and the current cash price. We will, however, emphasize the difference in the two prices, the basis, as an alternative to direct modeling of the futures price. Notation is summarized in Table 1.

Table 1. Variable Definitions

Symbol	Definition
Endogenous variables:	
I	Inventory
F	Futures price
P	Cash price
B	F - P = Basis
Q	Consumption
Predetermined variables:	
i	Interest rate
a	Demand shifter (level)
S	Production
Subscripts:	
1	Current period
2	Future period
(expectations formed in 1 are for period 2)	

A supply of storage equation is key to understanding, so I go back to first principles to discuss it. For simplicity, price (basis) risk is set aside, and the short-run profit equation (ignoring fixed costs) is written as

$$R_2 = F_1 I_1 - P_1 I_1 - C(I_1).$$

In this notation, F_1 is the period 1 price for delivery in period 2; thus, firms carrying inventory can buy inventory and simultaneously sell a forward contract at the respective prices. The storer's revenue is realized in period 2.

The cost function is assumed to have three components and is specified as

$$C(I_1) = iP_1 I_1 + dI_1 - v\ln I_1.$$

The first component represents the opportunity cost of carrying inventory from one period to the next, based on an interest rate, i, and the price level, P. The second component assumes that short-run costs, like wages and energy prices, are a linear function of the level of inventory.

The third component represents the convenience yield of carrying stocks; such convenience is thought to be large when stocks are small, but to decrease as stocks increase. While convenience yield is a vague and somewhat controversial subject, it is clear that in practice F_1 can be well below P_1, at least at the par delivery location, and the model must be

flexible enough to permit positive inventories when the price for future delivery is below the current price. Thus, the model specifies a negative cost (benefit) that is nonlinear in inventories, specifically a function of the logarithm of I.

Costs also could include a risk premium, which could be incorporated into the second component. For simplicity they are ignored. If they exist, they are tiny (Kamara).

Substituting the cost function into the profit function, taking the derivative of profits with respect to I, and solving this first-order condition, a supply of storage equation is obtained. It is common to write it in inverse form as

$$F_1 - P_1 = (iP_1 + d) - v/I_1 = m - v/I_1.$$

This equation, of course, is just a specific form of the profit maximization rule that marginal revenue equals marginal cost. In this model, marginal costs depend on the opportunity cost of storage, the direct costs of storage, and convenience yield. The left-hand side of the equation is a basis or a price of storage, which can be denoted B_1. The price of storage can be negative with positive, but small inventories. As inventories increase, the price of storage increases, but in this specification reaching an asymptote, m.

The development of a demand for storage equation has been more problematic in the literature (Telser; Peck). An approach that provides useful insights is to consider period one and period two demands for current consumption.

$$Q_1 = a_1 + bP_1,\ b < 0, \text{ and}$$
$$Q_2 = a_2 + bF_1.$$

In the simpler two period model, production, S_1, occurs in period one and is predetermined.

$$S_1 = Q_1 + Q_2, \text{ and } I_1 = Q_2.$$

Setting $Q_1 = S_1 - I_1$ and $Q_2 = I_1$, substituting the Q's out of the demand functions, and subtracting period one demand from period two demand, gives

$$I_1 = (1/2)(a_2 - a_1) + (b/2)(F_1 - P_1).$$

This approach makes the demand for storage dependent on expected demand for consumption in period two relative to the demand in period one for current consumption.

Thus, the model allocates production between current consumption and inventory (future consumption), and it determines the current price level and the difference in prices. Production S_1, the interest rate i, costs d, the level of current demand, a_1, and the level of expected demand, a_2, are treated as known. The model does not explain how expected demand for period two is formed, and a more complete specification would include the determinants of demand. The model also does not deal with interest rates and other factors affecting costs, which may not be completely certain at the beginning of the storage. In other words, expectations about a lot of variables may be important in price determination.

It is useful to note here that the model could be generalized to include more than two periods, though the model becomes more complex analytically. Nonetheless, the general notions can be introduced using the linkages between periods defined by identities like

$$I_1 = S_1 + I_0 - Q_1.$$

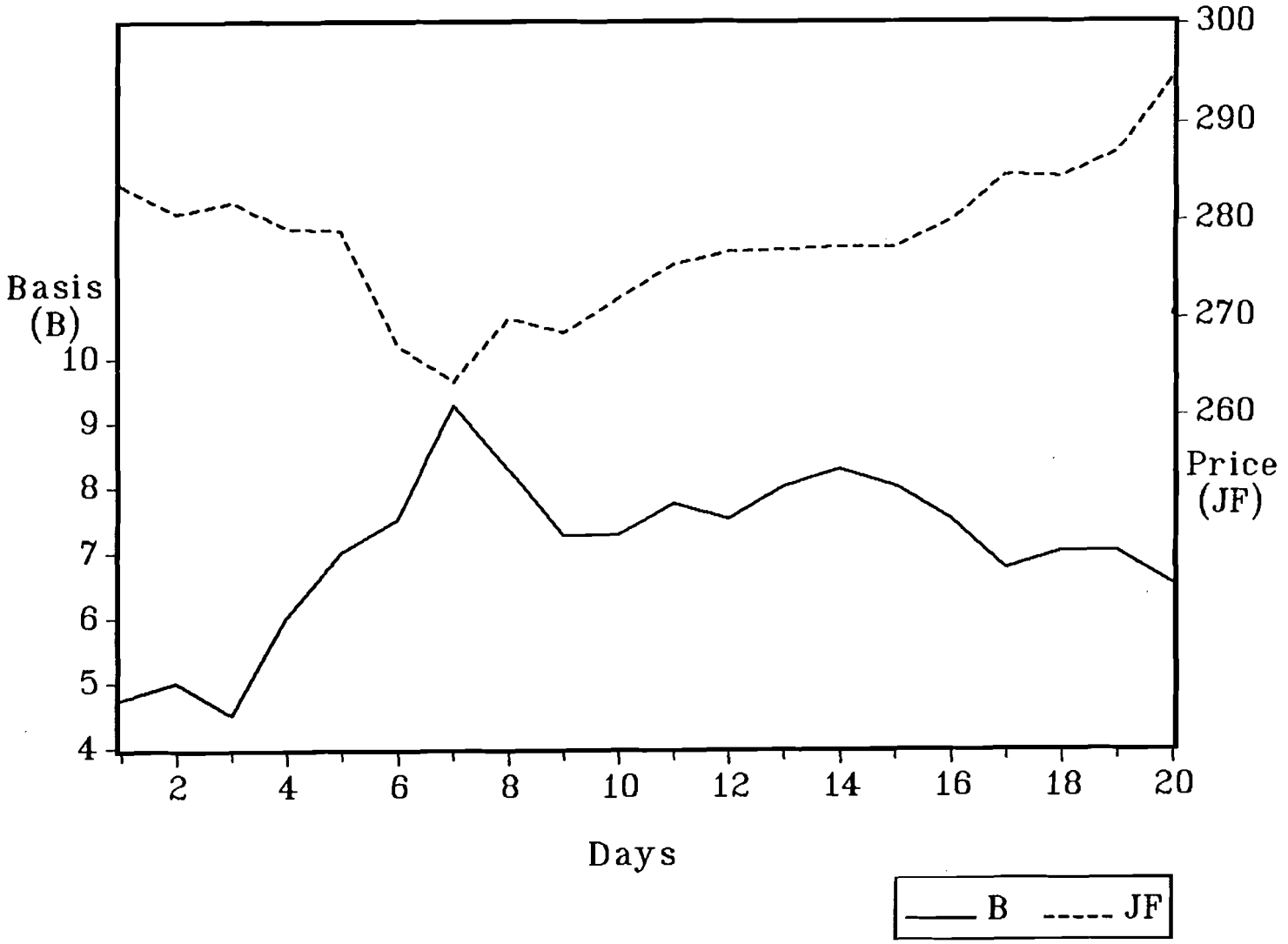
A similar identity holds for subsequent periods. Using these identities, the demand for holding inventory can be shown to depend not only on current and expected demand (implied by the a's of the demand equations), but also on the size of current supply relative to expected future supplies. Logically, the carryover from one crop year to the next depends on the size of the previous crop and on the size of the expected crop. Thus, a generalization requires that expectations about future production and inventories be added to expectations about future demand in the price determination process.

The price level, P, and the price of storage (basis), B, are specified as simultaneously determined. The model can also be viewed as explaining the two price levels, F and P, but only two independent pieces of information exist about prices, not three. It is in this context that Tomek and Gray (p. 373) emphasized that futures prices reflect "no prophecy that is not reflected in the cash price and is in this sense already fulfilled." The two price levels are dependent on precisely the same set of explanatory variables. They differ by the basis, which reflects the temporal difference in delivery time, but their changes depend on the same factors (the reduced form equation variables).

Specifying the model as a price level and a price difference has the benefit of making the price of storage explicit. It is consistent with Working's view of futures markets as establishing a price level and prices of storage, which relate to the various maturities of futures contracts. Futures prices for storable's are not independently established forecasts for various maturity months, but are linked to each other and to cash prices.

To further set ideas, a price difference and a price level for corn are illustrated in Figure 1 for 20 trading days, June-July 1995. The sample is arbitrary in that the prices were those occurring at the time the first draft of this paper was being written, but it is a good example in the sense that changes in expected supply are likely to be a relatively important influence on prices in this particular period. The price of July futures, observed just before maturity of contract, can be treated as the spot price, and the differences between the prices of the May 1996 and December 1995 futures, observed in Summer 1995, measure a price of storage for the forthcoming crop year.

Figure 1. May–December Spread and July Price Level, Corn, Chicago Board of Trade, June 19 – July 17, 1995



The Figure suggests a plausible inverse relationship between the (simultaneously determined) prices. Each series is being observed near the end of the 1995-96 crop year, hence during the growing season for the new crop to be harvested in Fall 1996. If the main factor affecting prices in July is changes in the expected harvest, increases in price levels are associated with decreases in expected production. At the same time, a smaller crop implies a smaller expected demand for storage during the next year, and hence a smaller price of storage. The price level and the price difference, for intrayear storage, are inversely related, even though the three measures of price level (July, December, and May futures) are highly positively correlated.[1]

The July price of the May futures reflects expectations about, among other things, production **and** the amount expected to be stored until May. In this sense, the July 1995 quote of the May 1996 futures price is a forecast, but it can only summarize information available in July. If realized production or other factors differ from July expectations, as they likely will, then the realized May price will differ from the July market "forecast." Indeed, the price of the May futures on May 15, 1996 was about $5.00 per bushel. The market seriously underestimated the maturity-time price of the May futures contract during the previous summer. Assuming the corn market is efficient, it incorporated all of the information available, but this did not guarantee an accurate forecast for the subsequent May.

In sum, F_1 can be viewed as an expected cash price at contract maturity. But F_1 is based on the same information set that determines P_1 and on information that determines the price of storage. Depending on inventory size, the price of storage can be negative or positive. Typically, the price level changes are larger than price difference changes.

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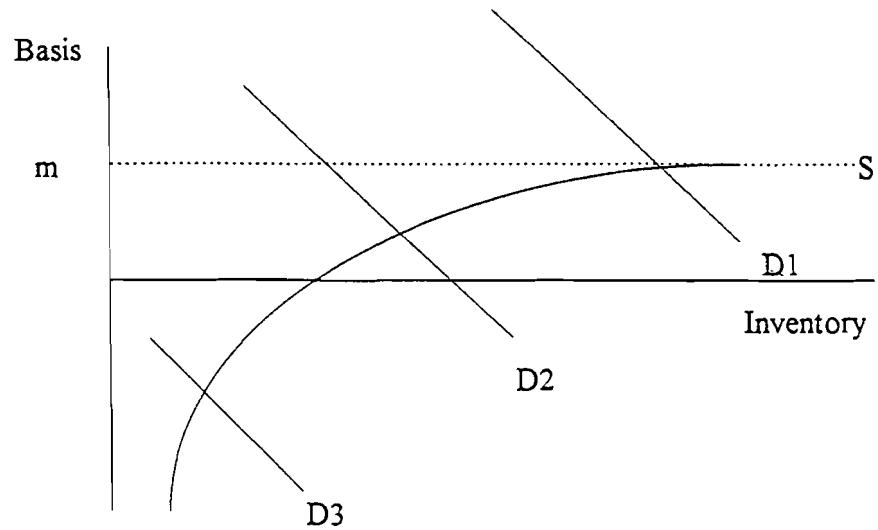
[1] The correlation coefficients among the three price levels used in this paper all exceed 0.93. In July 1995, prices were available for eight corn futures contracts (through December 1996 delivery), and the Chicago Board of Trade was listing contracts (with occasional transactions) through December 1997. In effect, it was possible to price corn for three different crop years in the late Spring and Summer of 1995, and thus the three prices used in this paper are only illustrative of a richer data set. In using daily prices, however, I do not mean to imply that one could fit a structural model to them. Clearly, daily observations are not available on the changing expectations affecting prices, and July prices ranged between 263.5 and 294.5 cents per bushel in the 20 days of the sample, implying considerable changes in the factors affecting prices. Also, while perhaps not obvious from Figure 1, the basis was trending. A descriptive regression equation for the data is

$$B = 48.2 - 0.147JF + 0.163TRD,\ R^2 = 0.83,\ DW = 1.85,$$

where the basis (B) and the July futures price level (JF) are in cents per bushel and TRD is a linear trend variable, changing one unit each day. The t-ratios are all 7.4 or larger, but recalling the simultaneity in prices and given other possible econometric problems, the equation merely emphasizes that other factors can influence the basis even over a short time period. This reinforces a general point of this paper, namely that the constellation of futures prices at any point in time are reflecting many economic forces.

Tomek and Gray (pp. 378f) stated that, because of the correlation between cash and futures prices, routine annual hedging in futures may not stabilize revenue; the price of the harvest-time futures at planting time can be, they argued, just as variable as the harvest-time price. The foregoing model suggests, however, that this argument is wrong, or at least exaggerated. For example, in Figure 2, shifts in the demand for storage are shown along a static supply of storage function. For large inventories, F_1 is constrained to a constant difference above P_1 by the nature of the marginal costs of storage (and by arbitrage which equates the price difference to the marginal cost of storage). Thus, for large levels of I, cash prices and futures prices are changing by about the same amounts. If demand shifts, the price level would change, but not the price differences.

Figure 2. Supply and Demand for Storage



This is not true, however, when inventories are small. In times of scarcity, like the corn and wheat markets in the Spring of 1996, the current cash price can be much higher than prices for distant futures. When cash corn was $5 per bushel in May 1996, the price for December 1996 delivery was about $3.60 per bushel and the price for May 1997 delivery was approximately $3.65 per bushel. With small stocks, a shift in demand causes both the price level and the price differences to change.

The nature of these changes is such that the price of the distant future is less variable than cash prices. When inventories are large, a limit exists on the amount that futures price can exceed the cash price; this limit is determined by the "d" and "iP" terms in the cost of storage function. When inventories are small, cash prices can be high relative to futures prices, and the "limit" on this relationship is the nature of the convenience yield of stocks. Experience indicates that cash prices can indeed be extremely large relative to distant futures.

Consequently, with a sufficiently long sample, one should observe, for grain markets, that current prices of distant futures are less variable than the subsequent cash prices and hence that routine hedges should reduce the variability of annual revenue. In Tomek and Gray, the variance of futures prices at planting time was only slightly smaller than the variance at harvest for soybeans and corn based on a 1952-68 sample period. This was a period of generally large stocks. Using 1974-95 price data for the December corn contract, Zulauf, et al. found that the standard deviation was 38 cents per bushel on May 1 and 54.7 cents on December 1. For November soybean prices, the standard deviation was 83.7 cents per bushel on May 1 and 115 cents per bushel on November 1. Clearly for the more recent sample, the planting-time price of the harvest-time futures is less variable than the price at harvest.

Implications

Forecasting the Price Level

This subsection discusses three topics. The first is the relationship of prices generated by efficient/inefficient markets to forecasts generated by quantitative models. A second topic is the implications of the literature for differences in forecasting ability of efficient futures markets for different commodities. Then, I briefly discuss a few technical econometric issues.

Market-Based versus Model-Based Forecasts. If the foregoing model is a reasonable representation of a commodity (grain) market and if the market is weak form efficient (Fama), then current (time t) prices reflect the known information about all of variables determining prices, including traders' expectations. In this case, a forecast from a correctly specified econometric model should not be able to improve upon the market's estimate of prices. Both, by definition, incorporate the correct information about prices; i.e., they are unbiased forecasts.

If an econometric model outperforms the market (or vice versa), three interpretations are possible. One is merely that both are correct, that the differences reflect sampling error, and that if a sufficiently large sample is analyzed, no significant difference in forecasting performance would exist. The second interpretation is that one or the other is "wrong." If the market outperforms the model, the model is erroneously specified, or if the model outperforms the market, the market is inefficient. Just and Rausser's and Rausser and Carter's results are consistent with these explanations; it is unlikely that in practice, econometric models would consistently outperform markets (but for evidence that an expert outperformed a futures market, see Bessler and Brandt).

In comparing forecasts, it is also important to remember that a model can have superior forecasting performance in a statistical sense, but that this information is not sufficient to provide for profitable trades, i.e., does not have economic significance (Rausser and Carter). Forecasts require resources, and trades to take advantage of the information in forecasts have transactions costs. Hence, the costs of making and using forecasts may exceed the benefits of using them.

Still another possibility is that the market is weak form efficient, but not strong form efficient. Strong form inefficiency implies that an analyst has private information, which is superior to the market's: a superior econometric model and/or superior ancillary estimates of the variables used to make the forecasts. Thus, it is possible for this analyst to make forecasts

that outperform the market. Assuming these forecasts can be used to make profitable decisions, the analyst is "paid" for this better information.

Perhaps the most common model used to appraise the forecasting (efficiency) performance of futures markets has been

$$F_{t+i} = a + bF_t + e_{t+i}, \text{ or alternatively,}$$
$$F_{t+i} - F_t = a + (b-1)F_t + e_{t+i}.$$

Analogous to standard forecasting evaluation methods, F_t is the forecast and F_{t+i} is treated as the actual realization of price. In early work, such as Tomek and Gray, F_{t+i} was observed at or near contract maturity; subsequent research has used a variety of definitions of "i," hence of the price being forecast. In any case, this equation can be interpreted as a forecast evaluation tool, a la Theil.

The second variant emphasizes that in a weak form efficient market, the current price level has no significant ability to forecast a price change, i.e., $a = b-1 = 0$. The two variants are, of course, equivalent statements; the current price is the best estimate of the forthcoming price and has no ability to forecast changes. To compare with other forecasts, the market quote F_t is replaced with the alternative forecast.

Thus, in saying that one forecast is better than another, the emphasis has been on the coefficients "a" and "b." David Bessler (letter) reminded me that alternative forecasts can be unbiased, but have different variances of forecast error. A plausible hypothesis is that futures markets have more noise than the alternative forecasting methods, such as an econometric model. Information is costly and learning by traders in markets may be complex (Grossman and Stiglitz). Not all traders are equally well-informed; some traders are uninformed. Uninformed traders can contribute to random noise in observed prices. That is, the variance of price is larger, other things being the same, as the number of "irrational traders" increases (Stein, p. 229). In this context, forecasts from statistical models could contribute to learning and to improved social welfare (Irwin).

As noted above, varying definitions of the time subscripts and time lags have been used. The longer the lag between t and t+i (the larger is i), the larger the scope for changes in the variables explaining the price level. It is possible, indeed likely, that with the passage of time, significant changes in information will occur. Markets do not have perfect foresight. Consequently, the current price quote for a distant maturity month can be a poor forecast of the realized price simply because so many unforeseeable events can occur in the interim. The best available forecast today can be a poor one. (This point is summarized in the textbook by Leuthold, Junkus, and Cordier (p. 108), is discussed by French, but is sometimes ignored in research articles on the topic.)

In their discussion of futures as forecasting agents, Fama and French suggest an evaluation equation, which makes the change in the cash price a function of the basis at the time the forecast is made. Namely, letting P be the cash price, they use the model

$$P_{t+i} - P_t = a + b(F_t - P_t) + e_t.$$

This equation is equivalent to

$$P_{t+1} = a + bF_t + cP_t + e_t,$$

where the constraint $c = 1 - b$ has been imposed. (Heifner fitted the same model to corn data for Michigan in 1966.)

This equation is another way of looking at the arguments developed by Working (1953). For storable's, the structural model discussed in the previous section implies that the two price levels should be highly correlated, and if the null hypothesis that $b = 1$ can not be rejected, this is equivalent to saying that F (or, equivalently P) contains all of the information available at the point in time t. Thus, an evaluation equation specified in levels can have a large r^2, but have little or no ability to forecast price changes. Likewise, the basis at time "t" is unlikely to have significant ability to forecast price changes, but this does not obviate the fact that the current quote in a futures market can be the best (at least unbiased) forecast of the maturity-time price.

Forecasting Performance for Different Commodities. The literature makes another point, namely that the forecasting ability of futures markets can vary by commodity. For example, Working (1953, footnote 5) stated that "perishability of a product favors predictability of price change because it tends to eliminate expectations regarding subsequent prices as current price influences." This seems to have been an off-hand thought, which in light of subsequent models, is not true. The hypotheses in this literature derive, however, from the basic economics of alternative markets, not from differences in the efficiency of markets.

Working, Tomek and Gray, and French use a similar model, namely one for commodities with continuous inventories. And, as previously noted, changes in expectations about economic conditions in future periods thus affect current cash as well as futures prices. The strength of this linkage, however, is related to the size of inventories; when inventories are large, the basis is relatively constant; when inventories are small, the basis is variable, i.e., changes in prices for future delivery are less closely related to the current cash prices.

In this context, French conjectures that futures prices for the metals will have less predictive power than those for seasonally produced, continuously stored agricultural products. This hypothesis relates to the intrayear and interyear seasonality of agricultural prices. Within a year, futures prices are anticipating the seasonal increase in price, and between years, the current price of the new crop futures relative to the current cash price provides incentives or disincentives for carrying stocks into the new crop year. Tomek and Gray make a similar conjecture, but as previously noted, this information content can be small relative to changes in expectations that can occur before the maturity of the new crop futures contract.

The conceptual model in this paper (or in French) is not really applicable to commodities with discontinuous inventories between growing seasons, such as potatoes, onions, and apples; discontinuous inventories are equivalent to infinite costs of storage between crop years. For such commodities, Tomek and Gray hypothesized that the planting-time price of the harvest-time futures would be a poor forecast of the realized harvest price. At planting time, the harvest-time futures price is not linked to the current cash price, and the basis reflects no information about inventories to be carried to the next year. Moreover, little information exists at planting time

about expected changes in demand or supply for commodities like potatoes. Thus, F_t at planting time varies little from year to year.

Equation (7) in French helps elucidate the Tomek and Gray hypothesis. This equation can be written as

$$A = \text{var}[F_t - P_t]/\text{var}[P_{t+j} - P_t],$$

where F_t can be interpreted as the planting-time price of the harvest-time futures and hence the numerator is the variance of the planting-time basis. This ratio being small is equivalent to saying that relatively little information is available at time "t" about the prices that will prevail at time "t+j." In French's terms, the variance of the numerator is small relative to the variance of the denominator, and indeed Tomek and Gray found that the planting-time price of the harvest-time futures had no predictive power.

French and French and Fama attempt to extend arguments based on storage costs to animal product markets, but as discussed in a separate section, I argue that a more complex model is required. Covey and Bessler discuss whether or not futures markets **add** information content to that contained in cash prices and hence whether or not futures markets improve upon the predictive power of time-series models of cash prices. They hypothesize that futures markets for livestock should provide additional information that is not provided by grain markets.

As discussed above, a quantitative model--structural or time series--should not be able to provide better forecasts than price quotes from an efficient futures market. I interpret the Covey and Bessler hypothesis as exploring the marginal improvement that futures quotes might provide relative to models of cash prices and whether such improvements differ by type of commodity. In practice, however, this idea is difficult to test. Building good quantitative models for different commodities is not easy. Comparisons are difficult because of the lack of high quality price series for cash commodities and because of the lack of synchronous observations on cash and futures prices for agricultural commodities.

What is true, however, is that markets can differ in the kinds and amount of information available about the factors affecting prices. Also, the availability of inventories can help in adjustments to changes in expectations. In addition, markets may differ in efficiency, i.e., in their ability to adjust to changes in information.

As the foregoing structural model implies, however, many factors affect prices. The fact that corn prices in April include information about inventories does not mean that the April price of December corn will necessarily be a precise forecast of the subsequent December price. Much can change between April and December.

Technical Issues. A considerable portion of the agricultural economics literature in this area has been concerned with econometric issues in fitting the models. These have included the possibility of treating the efficiency of prices for different maturities separately (versus pooling data for all contracts into one equation), the effects of outlier's, the nature of the distributions of prices, and the possible bias of the OLS estimator in fitting models with a lagged endogenous variable (e.g., Elam and Dixon; Kahl and Tomek; Koppenhaver). Interestingly, most analyses

have not emphasized the possible simultaneity of the system. Thus, for example, basis forecasting models in the literature are perhaps best viewed as reduced form equations.

The econometric literature has been heavily motivated by the fact that estimates of "b" in price forecasting evaluation equations are less than one and that the longer the lag between "t" and "t+i" the further the estimated b is from one. This has been attributed variously to least squares bias (since F_t is a lagged endogenous variable), to short samples and/or outlier's, to the existence of risk premiums in prices, and to possible inefficiencies in markets.

Another branch of empirical analyses of futures prices suggests that futures prices are non-stationary in levels, and as Zulauf, et al. point out, evaluations of the forecasting performance of futures quotes have not considered the possible nonstationarity of the data. When nonstationarity is taken into account, using a French and Fama specification, Zulaf, et al. find that the planting-time futures quote is an unbiased forecast of the harvest-time price. Notwithstanding all of the statistical problems, the evidence frequently supports the hypothesis that futures prices are unbiased forecasts.

From a purely descriptive (rather inference) point of view, the $b < 1$ estimated by OLS means that the covariance of the two prices is less than the variance of F_t. The prior discussion implies that the longer the lag between the two prices the smaller their covariability. Many factors can intervene in the interim to affect the correlation of the two prices. Markets can be efficient, but they certainly don't have perfect foresight.

Forecasting the Basis

Considerable research has been done on modeling basis behavior (e.g., Hauser, Garcia, and Tumblin; Kahl and Curtis; Leuthold and Peterson; Taylor and Tomek). The number of forecasting analyses is small however, and much less research has been done on basis behavior than on the pricing efficiency of futures markets. Basis forecasts are potentially valuable because they can help support a variety of hedging decisions. As a consequence of the large number of basis relationships and possible kinds of hedges, it is important to be precise about the definition of the particular basis being modeled. My comments are limited to two types of models. One relates to inventories carried from one crop year to the next and related bases, the other to intrayear inventories. Models for interyear relationships use cash prices that pertain to a period near the end of the current crop year and futures quotes for the first contract in the new crop year. This basis measures the magnitude of the incentive for carrying stocks from one year to the next.

A model, like the one above, is intended to explain the variability of this basis (and other endogenous variables). If expected production for next year is small, then ceteris paribus the basis will provide incentives to carry stocks into the new crop year. Clearly, the size of inventory carried into the next year--and hence its effect on the price level--is conditioned by many variables, including the size of the previous crop. But, this does not invalidate the concept of the basis providing incentives, or disincentives, to the carrying of stocks from one year to the next and therefore of simultaneously influencing the price level.

A variant of this model considers, say, the harvest-time cash price and the harvest-time quote of the nearby futures contract. A forecast of a local basis may help farmers who are considering anticipatory hedges of a growing crop. The conceptual model, discussed above, implies that this basis can vary from year to year and that explaining this variability is potentially difficult. Hence, obtaining useful forecasts may be difficult. Among other things, they depend on the expected values of variables, which may be difficult to measure. Because of the difficulty of making ancillary forecasts of explanatory variables in structural models, it is not surprising that basis forecasts have often been made from simple time-series or naive models.

The second kind of basis model relates to intrayear basis changes, i.e., over some storage interval. The profit or revenue function for the potential inventory holder again provides a useful frame of reference. Here, define R to be the revenue obtained from hedged inventory.

$$R = (P_{t+j} - P_t)I_t + (F_t - F_{t+j})X_t.$$

In this notation, inventory is purchased, I, and futures contracts, X, are sold at time "t" with delivery expected in time "t+j." This notation is used to emphasize that the time of sale of inventory is variable. A common application is to think of "t" as representing harvest-time and "t+j" as some point in the storage period. The signs assume that the inventory is indeed sold and the futures position offset at "t+j."

This revenue equation can be rewritten to emphasize that with a hedge, the inventory holder earns the change in the basis, or basis convergence. Let

$$B_t = F_t - P_t \text{ and } B_{t+j} = F_{t+j} - P_{t+j},$$

then solve each for the respective P's and substitute the P's out of the revenue equation. This gives

$$R = (F_{t+j} - F_t)Q_t + (B_t - B_{t+j})Q_t + (F_t - F_{t+j})X_t.$$

Working (1953) emphasized that if $X = Q$ (the futures position equals the cash position), then the hedger earns exactly the basis change (convergence). If expected convergence equals the expected marginal cost of storage, the firm should store and hedge. In a perfect market, basis at contract maturity would be zero. Thus, basis convergence is exactly B_t, the initial basis.

In reality, convergence is not exact, but as suggested by Working (1953), the degree of convergence can be forecast using the initial basis as the explanatory variable. The simple model, suggested by Working (1953), and used by Heifner, Tomek, and others, makes the basis change over a storage interval a function of the initial basis.

$$B_t - B_{t+j} = c + dB_t + u_{t+j}.$$

In a perfect market, the equation would merely state the identity that the decrease in basis must equal the initial basis ($c = 0$, $d = 1$, and the errors are all zero).

In practice, the foregoing equation is a classic forecasting model. It can be fitted to historical data. For forecasting, the basis at time "t" is observable; it can be inserted into the estimated equation and the point forecast computed. Moreover, the standard deviation of forecast error can be estimated, which is a measure of basis risk. This is a potentially useful decision tool for firms who are considering carrying and hedging inventories, and limited evidence suggests that such equations for the grains have considerable predictive ability. In contrast, Working (1953) and Heifner argued in the context of grain markets, that the basis has relatively small ability to forecast price changes, which is consistent with arguments made in a previous section.

Given basis risk, the revenue or objective function, can be modified to allow for risk. In an optimal hedge, the quantity in the futures position will not exactly equal the quantity of inventory, but this is a topic of a large literature, outside the scope of this paper. Rather, the point here is that forecasting basis change is important to making a storage and hedging decision.

An interesting question, in light of the discussion of forecasting price levels, is whether an analyst can improve upon the simple basis convergence model. Does the basis at time "t" contain all of the relevant information for estimating the change in the basis? If it does not, does this mean that markets are inefficient?

If markets are assumed efficient in the sense of incorporating all available information, then as noted, an econometric model cannot improve upon the market's estimates. But, this answer may need to be modified in specific applications. General models of basis and price level behavior use "representative" cash prices, which sometimes are just the prices of futures contracts at maturity. Models of basis convergence typically are for particular locations; they involve specific local spot markets. It may be that such a model needs to include variables that are specific to that location (and its cash price), and/or relate to differing rates of convergence from year to year. It is also plausible that the cash market is less efficient than a futures market. Thus, when specific cash prices or bases are being forecast, a quantitative model may be valuable.[2]

Adam, Tilley, and Olbert specify and estimate a model for wheat that is in the spirit of the model used in this paper. They consider the basis change from June 20 to November 30, using Gulf Coast cash prices, as a function of the basis on June 20. Their model also includes such "predetermined" variables as carrying charges over the storage interval, production from June 1 to December 1 (analogous to expected production), forecast consumption from December 1 to March 1 (like a proxy for expected demand), and a stocks ratio on December 1. While these variables are observable ex post, they need to be estimated for ex ante forecasts. The model is used to study the effects of government programs on wheat stocks, and although the predetermined variables are statistically important in the simultaneous equations model, it is unclear whether they would improve ex ante forecasts. This is perhaps a fruitful area for further research.

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[2] It should be noted that basis variability associated with an inefficient cash market is not always bad. A good manager may be able to complete a hedge with a relatively favorable basis change.

Extensions to Livestock Futures

The model used in this essay is specified from the viewpoint of a grain market. Clearly it needs to be modified for livestock markets, say, the live cattle market. While inventories are relatively unimportant in explaining basis behavior for livestock commodities, temporal linkages exist among prices. Prices in the temporal constellation are less strongly correlated for livestock futures than for the grains, but those relations that do exist for livestock are more complex. They depend, in part, on the array of alternatives that producers face in the life cycle of animals. For example, choices are made about using heifers as replacements in the breeding herd versus feeding them for slaughter, and the choices made in "t" will influence outcomes in "t+i."

Presumably, the basis at time "t," using the current quote of a futures contract maturing in "t+i," does reflect existing information about the complex array of factors that is expected to influence the price change from "t" to "t+i." That is, the current price of a distant future presumably reflects expectations about future economic conditions. The (implicit) underlying model for livestock products, however, is more complex than the storage model discussed in this paper or in French or in Covey and Bessler. It appears to be an empirical question whether or not the time "t" basis for livestock products has more or less predictive power than the comparable basis for the grains. The evidence presented by Fama and French does not appear to be definitive on this issue.

One concluding concern is the quality of observations on cash prices in the analysis of any agricultural commodity. The changing nature of cash markets is making it more difficult to observe a consistent series of cash prices through time. Also, local cash markets may be relatively less efficient than futures markets, and the quality of prices depends, in part, on the resources devoted to eliciting and compiling the data.

Summary

Cash and futures markets for commodities provide an array of prices. The general level of these prices and the differences among them are influenced by a complex set of forces. Thus, we shouldn't be surprised that accurate price forecasts are difficult to make, especially when the forecast is for a period that is distant from the current time. Much new information can arise between the time the forecast is made and the actual price is realized. Thus, a futures price can be an unbiased forecast of the maturity month price, but have a large variance of forecast error.

In principle, both futures markets and quantitative models can provide unbiased forecasts, though given the existence of active futures markets, they would seem to be the cheapest source of public forecasts. A hypothesis is that quantitative models could be developed that have a smaller variance of forecast error than do the futures prices.

A different point is that markets differ in terms of their complexity and the nature of information available on which forecasts can be based. Viewing the futures quote as an expected spot price, the expectation is based on different information sets in different markets. In addition, markets may differ in their efficiency. Likewise, quantitative models vary in quality.

Finally, this essay should not be taken to mean that econometric analyses of markets have no value. Some firms will want to develop superior private information. And even if no difference exists between econometric models and futures price quotes in terms of bias, econometric models or composite forecasts may have smaller variances of forecast error. In any case, academics still want to understand the general forces affecting prices. As academics, however, we need to be realistic about what forecasting models can accomplish.

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