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AGRICULTURAL COMMODITY PRICE FORECASTING ACCURACY: FUTURES MARKETS VERSUS COMMERCIAL ECONOMETRIC MODELS

by

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AGRICULTURAL COMMODITY PRICE FORECASTING ACCURACY: FUTURES MARKETS VERSUS COMMERCIAL ECONOMETRIC MODELS*

Gordon C. Rausser and Richard E. Just**

I. Introduction

Futures markets are generally believed to contribute a positive social value for two substantive reasons. First, they provide a marketplace for the transferring of risk from producers to speculators via hedging. Second, they are generally thought to provide forecasts about prices in futures contract months and thus contribute important information to the process of decision making under risk in the related markets. This paper focuses on the second rationale and attempts to evaluate the price forecasting information embodied in agricultural futures market prices by comparing with commercial price forecasts available from other sources. To the extent that futures market prices are more accurate predictors of futures spot prices, the futures markets indeed supply a beneficial forecasting service.

Commercial forecasts of spot agricultural commodity markets have been available for only the last few years, so the question addressed by this paper has only recently become a researchable topic. The commercial forecasts are quarterly, refer to specific cash markets, and cover a number of commodities. The firms that generate and sell these forecasts, largely to agribusiness

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companies, include Chase Econometrics; Data Resources, Inc.; Doanes Agricultural Service, Inc.; and Wharton Econometric Forecasting Associates. Other firms provide qualitative rather than quantitative forecasts, i.e., range forecasts under alternative scenarios. The quantitative forecasts of the above-listed firms are generally based upon large-scale U. S. agricultural sector models which specify formal links among individual commodities.

Some of the literature on futures markets questions the quality of futures prices as forecasts (Working, 1942; Tomek and Gray; Labys and Granger). Working, for example, states that "it is not true that future prices afford forecasts of price change in the sense in which one speaks of the price forecasts of a market analyst." He goes on to state, however, that "neither is it true that future prices provide no sort of forecast of price change." In addition, much of the recent conceptual work on futures markets views futures prices as rationally based expectations (Danthine; Peck; Feder, Just, and Schmitz; Turnovsky; Andersen and Danthine). Some recent empirical evidence also strongly suggests that futures prices play an important role in the formation of producer price expectations as well (Peck; Gardner).[1/]

The chief difficulty with the literature on futures markets is that no comprehensive conceptual formulation has been advanced to explain their behavior. Of course, numerous partial conceptual frameworks have appeared in the literature including normal backwardation (Keynes; Hicks), convenience (Kaldor), storage (Working, 1949; Brennan), and stochastic search or

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1/ Much of the available literature on futures markets has interpreted futures prices as an expectation of the spot price at the specified contract date. Some of this literature has suggested that, if this expectation has appropriately formed, the futures price is an efficient price (Samuelson). Recently, however, Danthine has shown that, even if the futures price is not the expected spot price of the contract date, the market may be efficient. Others have shown that, with wealth effects and risk preferences, futures markets are not generally efficient (Figlewski).

informationally based theories (Grossman). None of these theories is sufficiently comprehensive to explain price levels and variations in forward markets. For example, a comprehensive formulation must admit (1) several groups of market both rational and irrational and informed and uninformed, (2) risk aversion, (3) wealth limitations, (4) imperfect capital markets, and (5) transaction and information costs.

In the case of econometric forecasting, a simple analogy can be established between the process of generating prices from futures markets and that generated from econometric models. System econometric models attempt to specify the causal links between predetermined (both exogenous and lagged endogenous) variables and jointly determined variables. In using these models for forecasting purposes, predetermined variables must be forecasted which in turn are transferred via estimated causal links into forecasted spot prices.

Clearly, errors can arise at two levels: (1) in the forecast of the predetermined variables and (2) in the estimated causal links. Both types of errors are frequently encountered in econometric forecasting with the latter fully documented in the econometric literature as specification errors--e.g., omitted variables, inappropriate functional forms, measurement errors, aggregation, and the like. In the case of futures markets, the process has not been quantitatively specified; but in a qualitative or judgmental sense, the aggregate mental process of the market must perform much the same role as the econometric model. The aggregate judgmental views of all participants must form expectations or forecasts of important exogenous influences, e.g., planning intentions, yields, consumption, export demand, etc., and transmit this information into a futures price. Errors can be made in formulating forecasts of the exogenous information or in the transmission of this information into an observed futures price.

The efficiency norm established in the literature on futures markets serves as a basis of comparison for specification errors in the transmission of exogenous information into observed futures prices. These errors can emanate from irrational market participants, uninformed market participants, risk aversion, wealth limitations, imperfect capital markets, and alternative transaction and information costs. There is no evidence, empirical or a priori, which demonstrates that these error sources are more or less important than the specification errors that arise in econometric models.

One means of evaluating the forecasting ability of futures markets is to investigate the predictive accuracy of futures market prices for subsequent spot prices relative to other forecasting methods--specifically, econometric forecasts. Such comparisons are not only operational but also useful to market participants. Moreover, they provide the basis for a preliminary assessment of the relative errors of futures prices versus econometrically generated prices. With this in mind, the basic spirit of this paper is to detemine the accuracy of the futures market relative to other forms of price forecasting for various forecasting horizons.

Are futures markets more or less accurate than the econometrically based forecasts? Does the absolute and comparative accuracy depend upon the forecast horizon, e.g., is one more accurate for, say, a one-quarter forecast and another more accurate for a two-quarter or longer term forecast? Is the relative and absolute forecast accuracy commodity dependent? What improvements in forecasting accuracy can be achieved by formally combining futures markets and commercial econometric forecasts (Johnson and Rausser)?

This paper addresses the above issues by computing two statistical measure of equality, root mean squared error, of the Chase, Doanes, DRI, Wharton, and

futures market price forecasts of average quarterly cash market prices over the period 1976-1978. The commodities examined include corn, wheat, cotton, soybeans, soybean meal, soybean oil, hogs, and live cattle. Four different measures of quarterly futures price market forecasts are generated, and formal composite forecasts are derived. One-quarter through four-quarter forecast horizons are investigated.

II. The Futures Market Price Forecasts

For some commodities, several futures markets exist while for others only a single futures markets exists. Since our focus does not address a comparison of futures markets, we narrow the alternative price forecast possibilities by using the Chicago Board of Trade prices for wheat, corn, soybeans, soybean meal, and soybean oil; the New York Cotton Exchange for cotton; and the Chicago Mercantile Exchange for hogs and live cattle.

Given the specified markets and the desire to generate price forecasts, an issue arises as to the appropriate filter of futures market prices to use as a predictor of spot price for the contract month. One approach to this problem is to solve for an optimal filter of futures market prices in current months in predicting spot prices in contract months. The approach taken here, however, is more intuitive and is designed to be comparable with commercial forecasts which are be made at different times of the month. For example, if an econometric forecast is made in the early part of a month, futures prices may be observable only over the first week of the month. If a commercial forecast is made in midmonth, then futures prices in the midpart of the month, which presumably embody the latest information, may be more appropriate for comparison. If commercial forecasts are made late in the month, then all futures prices during the month may represent the available alternative information.

Or prices later in the month may entail more market information. Thus, the last price of the month may provide the best forecast of spot prices during the contract month.

Consistent with these considerations, four futures market prices are used to compare with the econometric forecasters:

1. The average of daily closing prices for the first (full) week of the month.
2. The average of daily closing prices for the midweek of the month.
3. The average of daily closing prices over the entire month.
4. The last-Friday closing price of the month.

In each case the prices are constructed from daily closing prices under the presumption that closing prices adequately reflect the information which has impacted on the market during a particular day.

Due to the quarterly temporal dimension of the econometric forecasts, an issue arises as to which contract month for a futures market should be used to represent the forecast horizon. That is, should an econometric forecast for live cattle price in the second quarter of, say, 1980 be compared with the corresponding April or June futures contract price? In some quarters only one contract exists so that no choice is available. In other quarters, however, two or three contracts may be applicable. For the purposes of this study, the midmonth in each quarter is used when available. If a contract does not exist for the midmonth, then the contract for the latter month is used since prices of these contracts would tend to use more of the information that would affect average quarterly spot market price than the first month contract. Of course, the first month contract is used if no other contract exists in the quarter.

Thus, the particular futures contract months which are thus used for comparison with the econometric forecasts are specified in Table 1.

III. The Commercial Forecasts

To determine an appropriate set of time periods for comparison, it is necessary to consider the operation of the commercial forecasting firms in terms of longevity and frequency of forecast. All four firms considered in this study began operation during 1976 with the first commercial forecasts in each case appearing in the latter half of 1976. The frequency and horizon of the respective forecasts thereafter are indicated in Table 2 for the eight major agricultural commodities examined by our analysis. In each case, firms made forecasts on a somewhat irregular basis initially but then settled down to a regular pattern in 1977. Since April, 1977, DRI's forecasts have been monthly and cover forecast horizons from one to eight quarters. Since June, 1977 (October, 1977, for soybean oil and meal), Chase has made forecasts with one- to eight-quarter horizons on a bimonthly basis. Wharton has forecasted from one to six quarters ahead nearly every month since April, 1977. Doanes has made forecasts less frequently—on a quarterly basis—for six of the eight commodities and has forecasted with a much shorter horizon of only two, three, or four quarters.

IV. The Basis of Comparison

Based on Table 2, the choice of an appropriate time period for the comparison is somewhat unclear. On the one hand, operations of the econometric forecasting firms were somewhat erratic until sometime in the first part of 1977. On the other hand, the need for reliable comparisons necessitates using

TABLE 1

Futures Market Contract Prices Use As
Predictors of Quarterly Spot Prices

Commodity	Market	Quarter			
		I	II	III	IV
Wheat	Chicago Board of Trade	March	May	September	December
Corn	Chicago Board of Trade	March	May	September	December
Cotton	New York Cotton Exchange	March	May	July	December
Soybeans	Chicago Board of Trade	March	May	September	November
Soybean meal	Chicago Board of Trade	March	May	August	December
Soybean oil	Chicago Board of Trade	March	May	August	December
Hogs	Chicago Mercantile Exchange	February	June	August	December
Live cattle	Chicago Mercantile Exchange	February	June	August	December

TABLE 2

Forecast Frequency and Horizon of Major
Commercial Econometric Forecasting Firms
July, 1976-December, 1978

Date of forecast	Wheat, corn, cotton, and soybeans				Soybean oil and meal				Hogs and live cattle			
	Chase	Doanes	DRI[a/]	Wharton	Chase	Doanes	DRI	Wharton	Chase	Doanes	DRI	Wharton
	quarters											
1976												
July	b/						8					
August		3	8							3	8	
September	7								7			
October	6								6			
November		3	8				8			2	8	
December	7			8				8	7			8
1977												
January			7									
February	7	3	8	7			8	7	7	3	8	7
March												
April	6	4	8	6			8	6	6	2	8	6
May			8	6			8	6			8	6
June	8		8	6			8	6	8		8	6
July			8	6			8	6			8	6
August	8	4	8				8		8	3	8	
September			8	6			8	6			8	6
October	8		8	7	8		8	7	8		8	7
November		4	8				8			2	8	
December	8		8	7	8		8	7	8		8	7

(Continued on next page.)

TABLE 2—continued.

Date of forecast	Wheat, corn, cotton, and soybeans				Soybean oil and meal				Hogs and live cattle			
	Chase	Doanes	DRI[a/]	Wharton	Chase	Doanes	DRI	Wharton	Chase	Doanes	DRI	Wharton
	quarters											
1978												
January			8	6			8	6			8	6
February	8	3	8	7	8		8	7	8	3	8	7
March			8	7			8	7			8	7
April	8	4	8	6	8		8	6	8	2	8	6
May			8	6			8	6			8	6
June	8		8	6	8		8	6	8		8	6
July			8	5			8	5			8	5
August	8	4	8	5	8		8	5	8	3	8	5
September			8				8				8	
October	8		8	7	8		8	7	8		8	7
November		4	8	7			8	7		2	8	7
December	8		8	8	8		8	8	8		8	8

a/ Reports a forecast also for cotton price made in April, 1976, but this forecast was excluded from the analysis because other firms were not operating in comparable time periods.

b/ Blanks indicate no forecast.

as many forecasts as possible. In addition, because not all forecasting firms have been making forecasts at the same points in time, a concern arises about comparability. Conditions may exist which, by chance, imply more instability and involve less information for one firm's forecast than for another's. For example, part of Doanes' and DRI's forecasts for corn in 1976 are made before the corn harvest while Wharton's only corn forecast in 1976 was made after the corn harvest was essentially complete.

In view of these considerations, two sets of comparisons are developed in this paper. The first set of comparisons is based on the best forecast available from each source by month for the period December, 1976, through December, 1978. The forecasts prior to December, 1976, are excluded from the analysis since not all four firms began forecasting on a commercial basis until that time. Moreover, at the time of this study, actual prices for the second quarter of 1979 were not yet available, so there was no point in considering forecasts made after December, 1978. The use of the term, "best available" forecast, implies that each firm's forecast in each month is taken to be their latest published forecast. For example, if Doanes makes a forecast in April, 1977, and then does not make another forecast until August, 1977, then the April forecast is used as Doanes' best available forecast in the months of May, June, and July. For customers who need price forecasts on a regular basis for decision-making purposes, it seems that this type of comparison is more meaningful than simply comparing the forecasts only over the set of months in which they are actually made. Admittedly, however, the comparison should tend to be biased in favor of DRI which revises its forecasts monthly and against Doanes which revises its forecasts only quarterly.

To determine the extent of this bias and to develop more information about the actual forecasting ability of each firm as opposed to the futures market,

a second set of comparisons was also constructed using only those months in which all firms (excluding Doanes) actually revised their forecasts. Thus, for all of the commodities except soybean meal and oil, the comparable months are February, April, June, October, and December of 1977 plus February, April, June, August, October, and December of 1978 (Table 2). The comparison for soybean meal and oil includes only these months beginning with October, 1977 (Table 2). These comparisons are still not strictly fair to Doanes, but using those months where all four firms revise forecasts would yield only four observations--certainly such data do not provide the basis for drawing reliable inferences.

These two sets of comparisons are developed using two statistical measures of quality--root mean squared error and root mean squared percentage error. Due to time limitations and the desire to simplify the reporting of results, other measures of quality are not investigated here. Moreover, as suggested by the St. George et al. study, other types of measures—such as mean absolute deviation and Theil U coefficients--generally lead to the same rankings of forecasts for the forecasting problem considered here.

Finally, note that each of the econometric firms do not forecast the same actual price series (Appendix A). Thus, problems arise regarding comparability due to transportation costs and other such factors which cause a divergence of prices in different markets. Also, in using futures market prices as forecasts of spot market prices, one must consider other factors such as capital costs, commissions, and risk which may be reflected in futures prices. To account for the effect of these factors in making the comparisons without actually isolating the individual effects, it is assumed that the basis (or difference in prices) due to these factors is approximately constant (at least over the two-year year period of this study) either in an additive sense or in

a multiplicative sense. Thus, the price forecasts are analyzed only in terms of their deviations from longer term average levels either in an absolute or percentage sense. In the former case, which corresponds to a constant additive basis, the comparisons are made using the root mean squared error where the error is given by

$$(\hat{p}_{t,t+h} - \hat{\bar{p}}) - (p_{t+h} - \bar{p}) = (\hat{p}_{t,t+h} - p_{t,t+h}) - (\hat{\bar{p}} - \bar{p})$$

where

$\hat{p}_{t,t+h}$ = forecast of price for time t + h made at time t.

$\hat{\bar{p}}$ = average of forecasted prices over the period covered by the root mean squared error calculations.

p_t = actual price at time t.

$\bar{p}$ = average of actual prices over the period covered by the root mean squared error calculation.[1/]

h = forecast horizon.

The root mean squared percentage error which corresponds to a constant multiplicative basis is calculated as the root mean square of[2/]

$$\frac{\hat{p}_{t,t+h} - \hat{\bar{p}}}{\hat{\bar{p}}} - \frac{p_t - \bar{p}}{\bar{p}}.$$

1/ Note that, to maintain equal weightings for actual quarterly prices, the means are computed using only one forecasted and actual price per quarter. To increase comparability, these were selected so as to correspond to new forecasts for as many firms as possible.

2/ To allow for the possibility of a changing basis, statistics of comparison were also developed on the basis of first differences, e.g., the root mean square of $(\hat{p}_{t,t+h} - \hat{p}_{t-1,t+h-1}) - (p_{t+h} - p_{t+h-1})$, but these statistics can penalize forecasts for frequent revisions even when forecasts are relatively accurate.

V. The Comparison of Forecasts

The statistics discussed above are reported in Tables 3 through 10 for the eight respective commodities. For those cases where the econometric firms are forecasting different spot prices, the futures market prices are evaluated as forecasters of each of the spot prices used by econometric forecasters.[1/] As can be seen, there are some rather surprising differences in the performance of the futures markets as forecasters of the different spot market prices. The largest differences, however, occur with cotton (Table 5) which is explained by the fact that DRI uses cotton lint price whereas other firms use actual cotton prices. Since the two are really different products, the results are not surprising. For this reason, however, the comparison of forecasts of cotton price, at least in the case of DRI, must be interpreted with some caution. Similar concerns must also be borne in mind for the firms which use different price series for the other commodities, i.e., Doanes for wheat, corn, and soybeans and DRI for wheat.

A careful evaluation of these differences can, in fact, suggest the extent to which the assumption of a constant basis is applicable. That is, if the actual price series differ by a constant basis, either additively or multiplicatively, then the futures market should forecast both or all three actual price series with the same root mean squared error either in absolute or percentage terms. With this in mind, one can note that there are some differences in both senses in the performance of the futures market as a forecaster of different spot prices. However, except in the peculiar case of cotton, the

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1/ In the case of wheat, however, the futures market is compared to the spot price in Portland, which is only one of the spot prices averaged together with Kansas City price, to arrive at the actual price series employed by DRI.

TABLE 3

Wheat: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models, December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time[a]			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	.279--25 (9.6)	.338--22 (11.6)	.386--19 (13.3)	.480--16 (16.5)	.254--11 (8.7)	.323--9 (11.1)	.362--8 (12.5)	.490--6 (16.9)
Doanes	.323--25 (12.4)	.401--22 (15.4)	.440--18 (16.9)	.588--7 (22.7)	.308--11 (11.8)	.394--9 (15.1)	.383--8 (14.8)	.512--3 (19.7)
DRI	.318--25 (10.4)	.474--22 (15.6)	.561--19 (18.0)	.668--16 (21.5)	.295--11 (9.9)	.435--9 (14.2)	.480--8 (15.4)	.589--6 (18.9)
Wharton	.266--25 (9.1)	.368--22 (12.7)	.440--19 (15.2)	.589--16 (20.3)	.212--11 (7.2)	.335--9 (11.5)	.374--8 (12.9)	.578--6 (19.9)
Futures market as a forecast of No. 1 Hard Red Winter, Kansas City prices								
First week average	.283--25 (9.7)	.367--22 (12.6)	.414--19 (14.1)	.600--3 (20.4)	.272--11 (9.3)	.349--9 (12.0)	.319--8 (10.9)	.438--1 (14.9)
Middle week average	.302--25 (10.3)	.393--22 (13.4)	.441--19 (15.0)	.659--3 (22.2)	.302--11 (10.3)	.413--9 (14.1)	.403--8 (13.7)	.556--1 (18.8)
Monthly average	.277--25 (9.5)	.371--22 (12.7)	.417--19 (14.2)	.605--3 (20.6)	.278--11 (9.5)	.375--9 (12.8)	.359--8 (12.3)	.480--1 (16.3)
Last Friday closing	.266--25 (9.1)	.365--22 (12.5)	.413--19 (14.1)	.586--3 (20.0)	.261--11 (8.9)	.364--9 (12.5)	.368--8 (12.6)	.490--1 (16.7)
Futures market as a forecast of average prices received by farmers								
First week average	.256--25 (9.2)	.333--22 (12.3)	.373--19 (13.7)	.597--3 (21.3)	.243--11 (9.0)	.312--9 (11.7)	.286--8 (10.6)	.412--1 (14.9)
Middle week average	.268--25 (9.5)	.357--22 (13.0)	.402--19 (14.6)	.654--3 (23.1)	.267--11 (9.7)	.377--9 (13.8)	.364--8 (13.2)	.530--1 (18.8)
Monthly average	.247--25 (8.9)	.335--22 (12.3)	.378--19 (13.8)	.602--3 (21.5)	.246--11 (9.1)	.339--9 (12.6)	.320--8 (11.8)	.454--1 (16.3)
Last Friday closing	.244--25 (8.6)	.332--22 (12.2)	.378--19 (13.8)	.581--3 (20.8)	.239--11 (8.8)	.330--9 (12.3)	.320--8 (11.9)	.464--1 (16.7)
Futures market as a forecast of export prices, Portland								
First week average	.252--25 (7.8)	.369--22 (11.2)	.440--19 (.3.5)	.690--3 (21.7)	.256--11 (8.0)	.366--9 (10.9)	.374--8 (11.4)	.422--1 (13.2)
Middle week average	.245--25 (7.6)	.377--22 (11.5)	.463--19 (14.2)	.744--3 (23.4)	.275--11 (8.5)	.416--9 (12.6)	.439--8 (13.5)	.540--1 (17.0)
Monthly average	.235--25 (7.3)	.363--22 (11.0)	.446--19 (13.7)	.693--3 (21.8)	.259--11 (8.0)	.386--9 (11.6)	.402--8 (12.3)	.464--1 (14.6)
Last Friday closing	.240--25 (7.6)	.354--22 (10.8)	.446--19 (13.8)	.670--3 (21.1)	.266--11 (8.4)	.374--9 (11.2)	.395--8 (12.0)	.474--1 (15.0)

a/ Note that the best available forecast is used for Doanes in periods where new forecasts are made by the other three firms.

TABLE 4

Corn: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models
December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time[a/]			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	.290--25 (12.3)	.346--22 (14.8)	.310--19 (13.2)	.264--16 (11.1)	.289--11 (12.3)	.337--9 (14.4)	.201--8 (8.4)	.307--6 (12.9)
Doanes	.339--25 (15.5)	.392--22 (18.0)	.355--18 (16.1)	.303--7 (13.4)	.364--11 (16.7)	.404--9 (18.5)	.235--8 (10.5)	.257--3 (11.5)
DRI	.246--25 (10.7)	.310--22 (13.4)	.300--19 (13.0)	.161--16 (6.9)	.249--11 (10.8)	.298--9 (12.9)	.097--8 (4.0)	.166--6 (7.3)
Wharton	.231--25 (10.0)	.264--22 (11.5)	.194--19 (8.4)	.181--16 (7.7)	.236--11 (10.3)	.249--9 (10.9)	.134--8 (5.7)	.122--6 (5.1)
Futures market as a forecast of No. 2 Yellow, Chicago prices								
First week average	.268--25 (11.4)	.328--22 (14.0)	.307--19 (13.0)	.188--3 (7.6)	.284--11 (12.1)	.348--9 (14.9)	.217--8 (8.9)	.094--1 (4.9)
Midweek average	.266--25 (11.2)	.341--22 (14.4)	.332--19 (13.9)	.274--3 (11.3)	.286--11 (12.1)	.366--9 (15.6)	.230--8 (9.4)	.264--1 (11.8)
Monthly average	.253--25 (10.8)	.333--22 (14.2)	.325--19 (13.7)	.232--3 (9.6)	.272--11 (11.6)	.351--9 (15.0)	.217--8 (8.9)	.214--1 (9.8)
Last Friday closing	.235--25 (10.0)	.339--22 (14.4)	.352--19 (14.9)	.254--3 (10.6)	.244--11 (10.5)	.342--9 (14.7)	.214--8 (8.9)	.271--1 (12.1)
Futures market as a forecast of average prices received by farmers								
First week average	.246--25 (11.0)	.319--22 (14.2)	.293--19 (12.9)	.223--3 (9.1)	.266--11 (12.0)	.332--9 (14.9)	.228--8 (9.5)	.008--1 (2.0)
Midweek average	.245--25 (10.7)	.330--22 (14.6)	.317--19 (13.8)	.290--3 (12.0)	.270--11 (12.0)	.347--9 (15.4)	.244--8 (10.2)	.178--1 (8.8)
Monthly average	.231--25 (10.3)	.322--22 (14.3)	.309--19 (13.6)	.252--3 (10.5)	.254--11 (11.4)	.333--9 (14.9)	.230--8 (9.7)	.128--1 (6.8)
Last Friday closing	.213--25 (9.4)	.327--22 (14.6)	.335--19 (14.7)	.265--3 (11.2)	.226--11 (10.3)	.323--9 (14.5)	.227--8 (9.7)	.185--1 (9.1)

a/ Note that the best available forecast is used for Doanes in periods where new forecasts are made by the other three firms.

TABLE 5

Cotton: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time[a/]			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	7.43--25 (12.5)	10.43--22 (17.5)	12.21--19 (20.5)	11.49--16 (19.3)	7.43--11 (12.5)	11.39--9 (19.1)	12.11--8 (20.4)	12.01--6 (20.2)
Doanes	6.53--25 (11.1)	8.39--22 (14.2)	8.47--18 (14.4)	6.58--7 (11.2)	6.35--11 (10.8)	9.38--9 (15.9)	8.23--8 (14.0)	7.01--3 (11.9)
DRI	5.52--25 (10.2)	8.31--22 (15.1)	11.29--19 (20.4)	14.53--16 (26.4)	6.09--11 (11.2)	9.59--9 (17.4)	12.88--8 (23.3)	14.62--6 (26.6)
Wharton	9.15--25 (15.5)	10.93--22 (18.6)	12.19--19 (20.9)	10.80--16 (18.5)	6.84--11 (11.6)	9.95--9 (16.8)	9.92--8 (16.9)	7.67--6 (13.1)
Futures market as a forecast of average prices received by farmers								
First week average	7.54--25 (11.6)	9.70--22 (15.1)	10.47--19 (16.4)	13.07--6 (20.4)	8.03--11 (12.3)	10.13--9 (15.9)	9.25--8 (14.5)	11.92--2 (18.5)
Middle week average	6.78--25 (10.2)	9.41--22 (14.5)	10.32--19 (16.0)	13.21--6 (20.3)	7.54--11 (11.3)	10.22--9 (15.9)	9.78--8 (15.2)	12.14--2 (18.6)
Monthly average	6.71--25 (10.2)	9.38--22 (14.6)	10.22--19 (16.0)	12.87--6 (20.0)	7.34--11 (11.1)	9.97--9 (15.6)	9.26--8 (14.5)	11.20--2 (17.3)
Last Friday closing	6.23--25 (9.4)	9.54--22 (14.8)	10.14--19 (15.9)	12.45--6 (19.3)	7.23--11 (10.9)	9.84--9 (15.4)	9.18--8 (14.4)	10.13--2 (15.7)
Futures market as a forecast of cotton lint, upland cotton, USDA prices								
First week average	6.02--25 (8.8)	6.72--22 (10.2)	8.23--19 (12.9)	10.49--6 (16.2)	6.17--11 (9.2)	6.81--9 (10.5)	8.09--8 (12.8)	9.75--2 (15.1)
Middle week average	5.64--25 (8.0)	6.48--22 (9.6)	8.08--19 (12.4)	10.59--6 (16.0)	6.22--11 (9.0)	7.06--9 (10.5)	8.34--8 (13.0)	9.57--2 (14.4)
Monthly average	5.52--25 (7.9)	6.39--22 (9.6)	7.92--19 (12.3)	10.24--6 (15.7)	5.87--11 (8.6)	6.71--9 (10.2)	7.87--8 (12.4)	8.75--2 (13.4)
Last Friday closing	5.50--25 (7.8)	6.57--22 (9.8)	7.82--19 (12.1)	9.84--6 (15.0)	5.86--11 (8.6)	6.72--9 (10.2)	7.80--8 (12.3)	7.70--2 (11.8)

a/ Note that the best available forecast is used for Doanes in periods where new forecasts are made by the other three firms.

TABLE 6

Soybeans: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time[a/]			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	1.58--25 (23.2)	1.12--22 (16.4)	1.04--19 (15.4)	1.16--16 (17.2)	1.64--11 (24.1)	1.19--9 (17.6)	1.03--8 (15.2)	1.28--6 (19.1)
Doanes	1.30--25 (19.9)	1.02--22 (15.6)	1.04--18 (16.1)	.91--7 (14.4)	1.39--11 (21.3)	1.01--9 (15.6)	1.01--8 (15.5)	.82--3 (12.9)
DRI	1.40--25 (20.4)	1.37--22 (20.0)	1.08--19 (15.8)	1.09--16 (16.1)	1.50--11 (21.8)	1.44--9 (20.9)	1.14--8 (16.7)	1.15--6 (17.0)
Wharton	1.47--25 (21.9)	1.46--22 (21.8)	1.40--19 (21.1)	1.25--16 (19.1)	1.62--11 (24.3)	1.63--9 (24.5)	1.54--8 (23.3)	1.34--6 (20.6)
Futures market as a forecast of No. 1 Yellow, Chicago prices								
First week average	1.47--25 (21.0)	1.20--22 (17.2)	1.09--19 (15.6)	1.04--9 (14.9)	1.70--11 (24.3)	1.25--9 (17.8)	1.13--8 (16.2)	1.07--4 (15.3)
Midweek average	1.37--25 (19.3)	1.24--22 (17.4)	1.15--19 (16.7)	1.08--9 (15.1)	1.53--11 (21.6)	1.20--9 (16.8)	1.10--8 (15.4)	1.07--4 (15.0)
Monthly average	1.35--25 (19.0)	1.22--22 (17.2)	1.11--19 (15.7)	1.04--9 (14.6)	1.52--11 (21.4)	1.19--9 (16.7)	1.08--8 (15.2)	1.04--4 (14.6)
Last Friday closing	1.28--25 (17.9)	1.25--22 (17.5)	1.18--19 (16.4)	1.09--9 (15.1)	1.36--11 (19.0)	1.18--9 (16.5)	1.09--8 (15.2)	1.07--4 (14.8)
Futures market as a forecast of average prices received by farmers								
First week average	1.39--25 (20.1)	1.10--22 (16.0)	.99--19 (14.3)	.96--9 (13.8)	1.61--11 (23.2)	1.13--9 (16.3)	1.02--8 (14.8)	.99--4 (14.2)
Midweek average	1.30--25 (18.5)	1.15--22 (16.4)	1.05--19 (14.8)	1.01--9 (14.0)	1.45--11 (20.6)	1.09--9 (15.4)	1.00--8 (14.1)	.97--4 (13.6)
Monthly average	1.27--25 (18.2)	1.12--22 (16.1)	1.01--19 (14.4)	.96--9 (13.5)	1.43--11 (20.4)	1.07--9 (15.2)	.97--8 (13.8)	.94--4 (13.3)
Last Friday closing	1.22--25 (17.2)	1.16--22 (16.4)	1.08--19 (15.1)	1.02--9 (14.0)	1.28--11 (18.0)	1.07--9 (15.0)	.99--8 (13.8)	.97--4 (13.4)

a/ Note that the best available forecast is used for Doanes in periods where new forecasts are made by the other three firms.

TABLE 7

Soybean Meal: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	11.19--15 (6.7)	11.38--12 (6.7)	21.11--9 (12.7)	31.64--6 (19.0)	10.98--8 (6.7)	11.92--6 (7.1)	18.18--5 (10.8)	31.12--3 (18.8)
DRI	43.66--25 (25.9)	46.29--22 (27.5)	26.07--19 (15.5)	26.77--16 (16.1)	16.47--8 (10.1)	21.48--6 (12.9)	21.36--5 (12.9)	33.48--3 (20.0)
Wharton	46.32--25 (28.0)	50.32--22 (30.5)	44.03--19 (26.8)	41.72--16 (25.5)	7.57--8 (4.6)	16.04--6 (9.7)	24.30--5 (14.6)	30.47--3 (18.4)
Futures market as a forecast of bulk 44 percent protein, Decatur prices								
First week average	45.78--25 (26.8)	35.91--22 (20.9)	28.86--19 (16.8)	26.32--10 (15.4)	10.93--8 (6.4)	9.53--6 (5.5)	9.57--5 (5.4)	18.51--2 (10.7)
Midweek average	42.06--25 (24.5)	36.35--22 (21.1)	28.93--22 (16.8)	23.99--10 (14.0)	11.13--8 (6.5)	10.10--6 (5.9)	11.55--5 (6.6)	19.44--2 (11.2)
Monthly average	41.63--25 (24.2)	36.19--22 (21.0)	28.47--19 (16.5)	24.33--10 (14.1)	10.51--8 (6.1)	9.89--6 (5.7)	11.56--5 (6.6)	19.55--2 (11.3)
Last Friday closing	38.62--25 (22.3)	35.81--22 (20.6)	28.84--19 (16.6)	24.24--10 (14.0)	9.48--8 (5.5)	9.95--6 (5.7)	14.21--5 (8.1)	22.10--2 (12.7)

TABLE 8

Soybean Oil: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	2.92--15 (12.8)	3.87--12 (16.8)	4.02--9 (17.8)	4.80--6 (21.5)	2.72--8 (11.9)	3.95--6 (17.1)	3.72--5 (16.4)	4.93--3 (22.1)
DRI	5.53--25 (23.2)	5.98--22 (25.0)	5.06--19 (21.3)	3.70--16 (16.1)	3.16--8 (13.7)	4.95--6 (21.1)	4.96--5 (21.3)	5.04--3 (21.9)
Wharton	5.05--25 (20.9)	4.73--22 (19.5)	3.62--19 (14.9)	2.41--16 (10.4)	2.72--8 (11.6)	3.36--6 (14.2)	3.27--5 (14.0)	3.26--3 (14.2)
Futures market as a forecast of crude tank, f.o.b., Decatur prices								
First week average	4.78--25 (19.8)	4.56--22 (18.7)	4.33--19 (17.9)	3.40--10 (14.3)	2.05--8 (8.7)	2.87--6 (12.0)	2.70--5 (11.5)	2.97--2 (12.9)
Middle week average	4.41--25 (18.3)	4.50--22 (18.4)	4.31--19 (17.7)	3.56--10 (14.8)	2.19--8 (9.4)	3.36--6 (14.0)	3.20--5 (13.6)	2.99--2 (12.9)
Monthly average	4.38--25 (18.0)	4.49--22 (18.3)	4.29--19 (17.6)	3.41--10 (14.2)	2.01--8 (8.6)	3.19--6 (13.3)	3.03--5 (12.8)	2.95--2 (12.7)
Last Friday closing	4.27--25 (17.5)	4.66--22 (18.9)	4.48--19 (18.2)	3.46--10 (14.3)	1.93--8 (8.2)	3.53--6 (14.6)	3.33--5 (13.9)	2.79--2 (11.8)

TABLE 9

Hogs: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time[a/]			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	3.49--25 (8.4)	4.87--22 (11.1)	7.20--19 (16.5)	9.16--16 (21.1)	3.43--11 (8.4)	4.93--9 (11.3)	7.10--8 (16.2)	9.41--6 (21.6)
Doanes	3.58--25 (8.3)	4.84--18 (11.2)	7.60--6 (17.6)	b/	3.54--11 (8.3)	4.56--9 (10.6)	8.66--2 (20.1)	
DRI	4.45--25 (10.0)	5.87--22 (13.1)	6.93--19 (15.4)	7.51--16 (16.6)	5.01--11 (11.2)	6.54--9 (14.6)	7.33--8 (16.3)	9.09--6 (20.1)
Wharton	4.16--25 (10.0)	5.11--22 (11.9)	5.38--19 (12.3)	6.29--16 (14.6)	3.77--11 (9.4)	6.14--9 (14.4)	5.50--8 (12.7)	6.84--6 (16.0)
Futures market as a forecast of 7 market average prices for barrows and gilts								
First week average	3.95--25 (9.0)	6.51--22 (14.6)	8.68--19 (19.4)	11.35--9 (25.4)	4.30--11 (9.7)	5.80--9 (13.0)	8.38--8 (18.7)	12.16--2 (27.2)
Middle week average	3.97--25 (8.9)	6.79--22 (15.1)	8.89--19 (19.8)	11.58--9 (25.8)	3.84--11 (8.6)	6.16--9 (13.7)	8.77--8 (19.5)	13.27--2 (29.5)
Monthly average	3.77--25 (8.5)	6.64--22 (14.7)	8.88--19 (19.7)	11.49--9 (25.5)	3.77--11 (8.4)	5.90--9 (13.1)	8.64--8 (19.1)	12.71--2 (28.2)
Last Friday closing	3.87--25 (8.6)	6.54--22 (14.5)	8.81--19 (19.5)	11.36--9 (25.1)	3.55--11 (7.8)	5.43--9 (12.0)	8.23--8 (18.1)	11.86--2 (26.2)

a/ Note that the best available forecast is used for Doanes in periods where new forecasts are made by the other three firms.

b/ Blanks indicate no data available.

TABLE 10

Cattle: Comparison of Best Monthly Forecast Available, Futures Markets, and Econometric Models December, 1976, Through December, 1978

Forecast	Best monthly forecast available				Comparison of forecasts made at the same points in time[a]			
	Forecast horizon (quarters)				Forecast horizon (quarters)			
	1	2	3	4	1	2	3	4
	root mean squared error--number of observations (root mean squared percentage error)				root mean squared error--number of observations (root mean squared percentage error)			
Econometric firm								
Chase	4.98--25 (10.1)	6.28--22 (12.8)	7.90--19 (16.1)	9.49--16 (19.4)	4.70--11 (9.5)	6.21--9 (12.6)	6.86--8 (13.9)	9.44--6 (19.3)
Doanes	5.92--25 (12.0)	6.22--18 (12.7)	6.36--6 (13.0)	[b]	5.79--11 (11.7)	6.25--9 (12.7)	5.23--8 (10.6)	
DRI	5.46--25 (11.2)	6.44--22 (13.2)	7.23--19 (14.8)	9.56--16 (19.6)	5.29--11 (10.8)	6.56--9 (13.4)	7.12--8 (14.6)	9.73--6 (20.0)
Wharton	5.76--25 (11.7)	6.80--22 (13.9)	7.22--19 (14.7)	9.73--16 (19.9)	6.06--11 (12.4)	7.52--9 (15.4)	7.15--8 (14.5)	9.98--6 (20.5)
Futures market as a forecast of choice slaughter steer price, Omaha								
First week average	4.58--25 (9.3)	6.67--22 (13.7)	8.47--19 (17.4)	11.16--9 (23.0)	4.23--11 (8.5)	7.19--9 (14.8)	8.01--8 (16.4)	12.86--3 (26.5)
Middle week average	4.54--25 (9.3)	6.80--22 (14.0)	8.73--19 (18.0)	11.22--9 (23.1)	4.33--11 (8.7)	7.47--9 (15.3)	8.54--8 (17.5)	13.52--3 (27.9)
Monthly average	4.41--25 (9.0)	6.63--22 (13.6)	8.62--19 (17.8)	11.20--9 (23.1)	4.22--11 (8.5)	7.20--9 (14.8)	8.40--8 (17.2)	13.33--3 (27.5)
Last Friday closing	4.60--25 (9.4)	6.63--22 (13.6)	8.65--19 (17.8)	11.47--9 (23.6)	4.66--11 (9.4)	7.05--9 (14.5)	8.32--8 (17.0)	13.64--3 (28.0)

a/ Note that the best available forecast is used for Doanes in periods where new forecasts are made by the other three firms.

b/ Blanks indicate no data available.

differences are not large. Only in a few isolated cases--such as wheat for a one- or two-quarter horizon and soybeans for a three-quarter horizon--do the results favor the constant additive basis over the constant multiplicative basis.

A further examination of Tables 3 through 10 also reveals some interesting quantitative relationships between alternative forecasters. For example, the variation in root mean squared errors and percentage errors among econometric forecasters is fairly large for given forecasting horizons for cotton, soybeans, soybean oil, and soybean meal with differences in root mean squared percentage error ranging from 5 percent up to over 10 percent. For cattle--and to a lesser extent corn, wheat, and hogs--on the other hand, all econometric firms maintain similar magnitudes of error. The differences among firms are particularly pronounced for soybean meal and oil.

Generally, Chase forecasts perform better for wheat, Wharton for corn, and Doanes for cotton and soybeans. For the other commodities, no one firm tends to perform better across all time horizons. Either Chase or Wharton perform better for soybean meal and oil depending on the standard of comparison. Chase seems to perform somewhat better for live cattle, and Wharton performs well for hogs in the longer horizons; but there is no clear dominance of one forecaster over another for the livestock commodities when all four horizons are considered together. Throughout these comparisons, however, one must bear in mind that very few observations were available for some of the longer horizons. Moreover, for many of the four-quarter forecasts as well as some three-quarter forecasts, the number of observations differs among forecasters (Tables 3 through 10); thus, results for the longer horizons are less reliable.

Turning to the four futures market forecasts, one finds a great deal of similarity. That is, all the futures prices tend to perform equally well as a forecast of a given spot price. There are a few interesting differences, however. For example, in most cases, the last Friday closing price tends to perform better than other futures price averages as a one-quarter forecaster but relatively worse as a four-quarter forecaster. These differences are indeed plausible, though, since last Friday prices do not precede next-quarter market conditions by nearly so long. On the other hand, the closing price from a single day's trading tends to be more variable then a weekly or monthly average. Thus, for long forecasting horizons where the quantity of relevant information is more comparable, the averages over longer periods in the futures market tend to be more accurate forecasts.

Finally, on the basis of Tables 3 through 10, consider the quantitative accuracy of forecasts with respect to time horizon. Generally, one would expect short horizon forecasts to be more accurate than long horizon forecasts. This is, indeed, the observed case for wheat, hogs, cattle, and most soybean derivative forecasts. On the other hand, the forecasts for soybean price seem to be more accurate for longer horizons than for short horizons. This observation may be due to an unusual market trend over the particular period of this study. But it could also be due to the relatively volatile nature of the soybean market. For example, the soybean futures market is generally thought to be a more active and fluctuating market which make it relatively attractive to speculators. For this reason, it may be that phenomena unrelated to the cash market may play a greater role in short-run trading and price fluctuations so that the more predictable market movements only tend to occur over a longer time horizon. Indeed, comparing across commodity markets on the basis of root mean squared percentage errors, the soybean market seems to be much

less predictable in the short run than other commodity markets (with the possible exception of soybean derivation markets). The corn and wheat markets, which are generally thought to be much less active and more stable, are more predictable over all four horizons (in a mean forecast sense) than the other commodities.

VI. Futures Markets Versus Econometric Forecasting

A major objective of this paper is to determine whether futures markets have merit as price forecasters. To develop some summary information in this respect, average rankings of econometric and futures forecasts are reported in Tables 11 through 18 for each comparison.[1/] That is, while a given econometric model may perform better for one commodity, all of the econometric models are supposedly based on a similar methodology. As Tables 11 through 18 reveal, no one model performs consistently better over all commodities (Chase is better for wheat, Wharton for corn, Doanes for cotton and soybeans, etc.). This variation in performance may be due to a randomness in characteristics vis-a-vis important market phenomena in 1977 and 1978. Thus, a general comparison of the econometric results with the futures results may provide a clearer picture of the a priori possibilities of developing an accurate econometric forecasting model.

Based on the average ranks in Tables 11 through 18, one can apply the Mann-Whitney testing procedure to determine, in a nonparametric context, whether futures markets forecast prices better or worse than commercial

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1/ Note that, for Tables 11 through 18, the futures prices are considered as forecasts only for the predominant actual price series used in econometric forecasting, i.e., the one used by most commercial forecasters. Thus, the rankings must be viewed with caution in the case of Doanes and DRI where they use different actual price series than other forecasters.

TABLE 11

Wheat: Rankings of Forecasts for Wheat Prices Based on the Predominant Actual Price Series[a/] December, 1976, Through December, 1978

Forecast	Best monthly forecast available, Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time, Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	4	1	1	1	2	1	3	3½
Doanes[b/]	8	7	5½	3	8	6	6	5
DRI[b/]	7	8	8	8	6	8	8	8
Wharton	1½	4	5½	4	1	2	5	7
Average rank	5.13	5.00	5.00	4.00	4.25	4.25	5.50	5.88
Futures market as a forecast of No. 1 Hard Red Winter, Kansas City prices								
First week average	5	3	3	5	4	3	1	1
Middle week average	6	6	7	7	7	7	7	6
Monthly average	3	5	4	6	5	5	2	2
Last Friday closing	1½	2	2	2	3	4	4	3½
Average rank	3.88	4.00	4.00	5.00	4.75	4.75	3.50	3.13
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	4	1	1	1	2	1	3	4
Doanes[b/]	8	7	7	8	8	8	7	7
DRI[b/]	7	8	8	6	6	7	8	6
Wharton	1½	4½	6	3	1	2	5	8
Average rank	5.13	5.13	5.50	4.50	4.25	4.50	5.75	6.25*
Futures market as a forecast of No. 1 Hard Red Winter, Kansas City prices								
First week average	5	3	2½	4	4	3	1	1
Middle week average	6	6	5	7	7	6	6	5
Monthly average	3	4½	4	5	5	5	2	2
Last Friday closing	1½	2	2½	2	3	4	4	3
Average rank	3.88	3.88	3.50	4.50	4.75	4.50	4.25	2.75*

a/ Fractional rankings indicate ties.

b/ Designed to predict a different price series than other econometric forecasts.

* Significant difference in futures and econometric forecasts in a 5 percent, two-sided sense.

TABLE 12

Corn: Rankings of Forecasts for Corn Prices Based on the Predominant Actual Price Series[a/]
December, 1976, Through December, 1978

Forecast	Best monthly forecast available — Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time — Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	7	7	4	6	7	3	3	8
Doanes[b/]	8	8	8	8	8	8	8	5
DRI	3	2	3	1	3	2	1	3
Wharton	1	1	1	2	1	1	2	2
Average rank	4.75	4.50	4.00	4.25	4.75	3.50	3.50	4.50
Futures market as a forecast of No. 2 Yellow, Chicago prices								
First week average	6	3	2	3	5	5	5½	1
Midweek average	5	6	6	7	6	7	7	6
Monthly average	4	4	5	4	4	6	5½	4
Last Friday closing	2	5	7	5	2	4	4	7
Average rank	4.25	4.50	5.00	4.75	4.25	5.50	5.50	4.50
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	7	7	4	6	7	3	3	8
Doanes[b/]	8	8	8	8	8	8	8	5
DRI	3	2	2½	1	3	2	1	3
Wharton	1½	1	1	3	1	1	2	2
Average rank	4.88	4.50	3.88	4.50	4.75	3.50	3.50	4.50
Futures market as a forecast of No. 2 Yellow, Chicago prices								
First week average	6	3	2½	2	5½	5	5	1
Midweek average	5	5½	6	7	5½	7	7	6
Monthly average	4	4	5	4	4	6	5	4
Last Friday closing	1½	5½	7	5	2	4	5	7
Average rank	4.13	4.50	5.13	4.50	4.25	5.50	5.50	4.50

a/ Fractional rankings indicate ties.

b/ Designed to predict a different price series than other econometric forecasts.

TABLE 13

Cotton: Rankings of Forecasts for Cotton Prices Based on the Predominant Actual Price Series[a/] December, 1976, Through December, 1978

Forecast	Best monthly forecast available — Forecast horizon (quarters) 1	2	3	4	Comparison of Forecasts made at the same points in time — Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	6	7	8	3	6	8	7	6
Doanes	3	2	1	1	2	1	1	1
DRI[b/]	1	1	6	8	1	2	8	8
Wharton	8	8	7	2	3	4	6	2
Average rank	4.50	4.50	5.50	3.50	3.00	3.75	5.50	4.25
Futures market as a forecast of average prices received by farmers								
First week average	7	6	5	6	8	6	3	5
Middle week average	5	4	4	7	7	7	5	7
Monthly average	4	3	3	5	5	5	4	4
Last Friday closing	2	5	2	4	4	3	2	3
Average rank	4.50	4.50	3.50	5.50	6.00	5.25	3.50	4.75
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	7	7	7	3½	8	8	7	7
Doanes	5	1	1	1	1	4	1	1
DRI[b/]	3	5½	6	8	4	7	8	8
Wharton	8	8	8	2	6	6	6	2
Average rank	5.75	5.38	5.50	3.63	4.75	6.25*	5.50	4.50
Futures market as a forecast of average prices received by farmers								
First week average	6	5½	5	7	7	4	3½	5
Middle week average	3	2	3½	6	5	4	5	6
Monthly average	3	3	3½	5	3	2	3½	4
Last Friday closing	1	4	2	3½	2	1	2	3
Average rank	3.25	3.63	3.50	5.38	4.25	2.75*	3.50	4.50

a/ Equal rankings represent ties.

b/ Designed to predict a different price series than other econometric forecasts.

* Significant difference in futures and econometric forecasts in a 5 percent two-sided sense.

TABLE 14

Soybeans: Rankings of Forecasts for Soybean Prices Based on the Predominant Actual Price Series[a/] December, 1976, Through December, 1978

Forecast	Best monthly forecast available — Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time — Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	8	2	1½	7	7	3½	2	7
Doanes[b/]	2	1	1½	1	2	1	1	1
DRI	5	7	3	5½	3	7	7	6
Wharton	6½	8	8	8	6	8	8	8
Average rank	5.38	4.50	3.50	5.38	4.50	4.88	4.50	5.50
Futures market as a forecast of No. 1 Yellow, Chicago prices								
First week average	6½	3	4	2½	8	6	6	4
Midweek average	4	5	6	4	5	5	5	4
Monthly average	3	4	5	2½	4	3½	3	2
Last Friday closing	1	6	7	5½	1	2	4	4
Average rank	3.63	4.50	5.50	3.63	4.50	4.13	4.50	3.50
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	8	2	1	7	6	5	2	7
Doanes[b/]	4	1	5½	1	2	1	5	1
DRI	5	7	4	6	5	7	7	6
Wharton	7	8	8	8	7½	8	8	8
Average rank	6.00	4.50	4.63	5.50	5.13	5.25	5.50	5.50
Futures market as a forecast of No. 1 Yellow, Chicago prices								
First week average	6	3½	2	3	7½	6	6	5
Midweek average	3	5	5½	4½	4	4	4	4
Monthly average	2	3½	3	2	3	3	2	2
Last Friday closing	1	6	7	4½	1	2	2	3
Average rank	3.00	4.50	4.38	3.50	3.88	3.75	3.50	3.50

a/ Equal rankings indicate ties.

b/ Designed to predict a different price series than other econometric forecasts.

TABLE 15

Soybean Meal: Rankings of Forecasts for Soybean Meal Prices Based on the Predominant Actual Price Series December, 1976, Through December, 1978

Forecast	Best monthly forecast available — Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time — Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	1	1	1	6	5	5	5	6
DRI	5	6	2	5	7	7	6	7
Wharton	7	7	7	7	1	6	7	5
Average rank	4.33	4.67	3.33	6.00*	4.33	6.00*	6.00*	6.00*
Futures market as a forecast of bulk 44 percent protein, Decatur prices								
First week average	6	3	5	4	4	1	1	1
Midweek average	4	5	6	1	6	4	2	2
Monthly average	3	4	3	3	3	2	3	3
Last Friday closing	2	2	4	2	2	3	4	4
Average rank	3.75	3.50	4.50	2.50*	3.75	2.50*	2.50*	2.50*
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	1	1	1	6	6	5	5	6
DRI	5	6	2	5	7	7	6	7
Wharton	7	7	7	7	1	6	7	5
Average rank	4.33	4.67	3.33	6.00*	4.67	6.00*	6.00*	6.00*
Futures market as a forecast of bulk 44 percent protein, Decatur prices								
First week average	6	3	5½	4	4	1	1	1
Midweek average	4	5	5½	1½	5	4	2½	2
Monthly average	3	4	3	3	3	2½	2½	3
Last Friday closing	2	2	4	1½	2	2½	4	4
Average rank	3.75	3.50	4.50	2.50*	3.50	2.50*	2.50*	2.50*

*Significant difference in futures and econometric forecasts in a 10 percent two-sided sense.

TABLE 16

Soybean Oil: Rankings of Forecasts for Soybean Oil Prices
December, 1976, Through December, 1978

Forecast	Best monthly forecast available — Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time — Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	1	1	2	7	5½	6	6	6
DRI	7	7	7	6	7	7	7	7
Wharton	6	6	1	1	5½	3½	4	5
Average rank	4.67	4.67	3.33	4.67	6.00*	5.50	5.67	6.00*
Futures market as a forecast of crude tank, f.o.b., Decatur prices								
First week average	5	4	5	2	3	1	1	3
Middle week average	4	3	4	5	4	3½	3	4
Monthly average	3	2	3	3	2	2	2	2
Last Friday closing	2	5	6	4	1	5	5	1
Average rank	3.50	3.50	4.50	3.50	2.50*	3.88	3.75	2.50*
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	1	1	4	7	6	6	6	7
DRI	7	7	7	6	7	7	7	6
Wharton	6	6	1	1	5	4	5	5
Average rank	4.67	4.67	4.00	4.67	6.00*	5.67	6.00*	6.00*
Futures market as a forecast of crude tank, f.o.b., Decatur prices								
First week average	5	5	5	3½	3	1	1	3½
Middle week average	4	3	3	5	4	3	3	3½
Monthly average	3	2	2	2	2	2	2	2
Last Friday closing	2	4	6	3½	1	5	4	1
Average rank	3.50	3.50	4.00	3.50	2.50*	3.75	2.50*	2.50*

*Significant difference in futures and econometric forecasts in a 10 percent two-sided sense.

TABLE 17

Hogs: Rankings of Forecasts for Hog Prices
December, 1976, Through December, 1978

Forecast	Best monthly forecast available — Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time — Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	1	2	3	3	1	2	2	3
Doanes	2	1	4	a/	2	1	7	
DRI	8	4	2	2	8	8	3	2
Wharton	7	3	1	1	4½	6	1	1
Average rank	4.50	2.50*	2.50*	2.00**	3.88	4.25	3.25	2.00**
Futures market as a forecast of 7 market average prices for barrows and gilts								
First week average	5	5	5	4	7	4	5	5
Middle week average	6	8	8	7	6	7	8	7
Monthly average	3	7	7	6	4½	5	6	6
Last Friday closing	4	6	6	5	3	3	4	4
Average rank	4.50	6.50*	6.50*	5.50**	5.13	4.75	5.75	5.50**
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	2	1	3	3	3½	2	2	3
Doanes	1	2	4		2	1	8	
DRI	7½	4	2	2	8	8	3	2
Wharton	7½	3	1	1	6	7	1	1
Average rank	4.50	2.50*	2.50*	2.00**	4.88	4.50	3.50	2.00**
Futures market as a forecast of 7 market average prices for barrows and gilts								
First week average	6	6	5	5	7	4	5	5
Middle week average	5	8	8	7	5	6	7	7
Monthly average	3	7	7	6	3½	5	6	6
Last Friday closing	4	5	6	4	1	3	4	4
Average rank	4.50	6.50*	6.50*	5.50**	4.13	4.50	5.50	5.50**

a/ Blanks indicate no data available.

* Significant difference in futures and econometric forecasts in a 5 percent two-sided sense.

** Significant difference in futures and econometric forecasts in a 10 percent two-sided sense.

TABLE 18

Cattle: Rankings of Forecasts for Live Cattle Prices[a/]
December, 1976, Through December, 1978

Forecast	Best monthly forecast available, Forecast horizon (quarters) 1	2	3	4	Comparison of forecasts made at the same points in time, Forecast horizon (quarters) 1	2	3	4
	(rankings of root mean squared error)				(rankings of root mean squared error)			
Econometric firm								
Chase	5	2	4	1	5	1	2	1
Doanes	8	1	1	b/	7	2	1	
DRI	6	3	3	2	6	3	3	2
Wharton	7	7½	2	3	8	8	4	3
Average rank	6.50*	3.38	2.50*	2.00**	6.50*	3.50	2.50*	2.00**
Futures market as a forecast of choice slaughter steer price, Omaha								
First week average	3	6	5	4	2	5	5	4
Middle week average	2	7½	8	6	3	7	8	6
Monthly average	1	4½	6	5	1	6	7	5
Last Friday closing	4	4½	7	7	4	4	6	7
Average rank	2.50*	5.63	6.50*	5.50**	2.50*	5.50	6.50*	5.50**
	(rankings of root mean squared percentage error)				(rankings of root mean squared percentage error)			
Econometric firm								
Chase	5	2	4	1	5	1	2	1
Doanes	8	1	1		7	2	1	
DRI	6	3	3	2	6	3	4	2
Wharton	7	7	2	3	8	8	3	3
Average rank	6.50*	3.25	2.50*	2.00**	6.50*	3.50	2.50*	2.00**
Futures market as a forecast of choice slaughter steer price, Omaha								
First week average	2½	6	5	4	1½	5½	5	4
Middle week average	2½	8	8	5½	3	7	8	6
Monthly average	1	4½	6½	5½	1½	5½	7	5
Last Friday closing	4	4½	6½	7	4	4	6	7
Average rank	2.50*	5.75	6.50*	5.50**	2.50*	5.50	6.50*	5.50**

a/ Fractional rankings indicate ties.

b/ Blanks indicate no data available.

* Significant difference in futures and econometric forecasts in a 5 percent, two-sided sense.

** Significant difference in futures and econometric forecasts in a 10 percent, two-sided sense.

econometric forecasters (significance in a 5 or 10 percent two-sided sense is indicated in Tables 11 through 18).[1/]

Using this approach, a significant difference is found in very few cases. The commercial econometric models perform significantly better than the futures market in one or three of four cases for hogs (depending on which comparison is used) and in two of four cases for live cattle. On the other hand, the futures market provides significantly better forecasts than the econometric models in possibly one wheat case and one cotton case, depending on the comparison; in one or three of four soybean meal cases, depending on the comparison; in as many as three of four soybean oil cases; and in one of four cases for live cattle. Consider further only those comparisons corresponding to new econometric forecasts (the right half of Tables 3 through 18). Because of decaying information in older forecasts, any improved performance with older forecasts may be attributed to noise. Thus, a seeming superiority of econometric forecasts over futures forecasts in the left half of Tables 3 through 18 may be simply due to chance. In the remaining comparisons the futures market is a significantly better predictor in from 6 to 9 of 24 cases while the econometric forecasts are significantly better for only 3 cases.

VII. Comparison of Futures and Econometric Forecasts by Time Horizon

Since traders in the futures market are often closer to cash market phenomena and since they are often able to make use of new information more quickly than econometric firms, one might expect the futures market to perform better as a short-term forecaster. On the other hand, econometric forecasts

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1/ The reader should bear in mind, however, that this test might be biased toward significance (although not in favor of one forecaster versus the other) because of nonindependence among futures market price averages or among econometric forecasts.

may be based on better structural information and more careful, longer run forecasts of exogenous forces. Thus, econometric forecasts may be expected to be superior for a longer forecasting horizon.

Indeed, examining only the more comparable results in the right half of Tables 11 through 18, the futures market is significantly favored in two of eight cases with one-quarter horizons while the econometric forecasts are favored in none. On the other hand, while the econometric forecasts are significantly favored in two of eight cases for a four-quarter horizon, the futures market is significantly favored in two or three of the remaining cases. The futures market similarly seems to dominate forecasts with two- or three-quarter horizons; the futures market is significantly favored in two or three cases while the econometric forecasts are significantly favored in, at most, one case for each horizon.

Examining the trends in average ranks with respect to forecast horizon (Tables 11 through 18), the expected relative improvement in performance for econometric forecasts vis-a-vis futures prices seems to be reflected only in the live cattle and, possibly, hog markets. On the other hand, it appears that futures market performance as a forecaster may be improving with time horizon for soybean meal. The performance of the econometric models for any time horizon in the case of soybean meal, however, is dismal.

At least, it appears that for grain markets, the futures markets prices carry a significant amount of useful information even on the long-term contracts. If econometric models can develop better forecasts than futures markets for long forecasting horizons, it may be only at considerably longer time horizons than for which futures contracts presently exist. The results of this paper thus suggest that there may be some positive social benefits to the development of longer term contracts in the futures markets for grains

and, particularly, the derivatives of soybeans. Of course, one must bear in mind, however, that these results are developed on the basis of a rather short period of observation of the commercial econometric forecasting firms, and perhaps their performance will improve with time.

VIII. Composite Forecasts

In the case of commodity spot prices, individual decision makers (traders, speculators, procurement managers, chief executives, etc.) face a bewildering barrage of differing and conflicting forecasts. Such decision makers seldom combine in any systematic way the individual forecasts available to them. One means of systematically combining such forecasts called "composite forecasting" has been recently developed. This approach assists in alleviating the confusion which arises with differing projections by establishing a balance among alternative forecasts and simultaneously generating more accurate forecasts. It explicitly recognizes that the best forecast should make use of all available information. The mechanics and properties of composite forecasting are described in Appendix B of this paper.

Tables 19 through 26 give the root mean squared errors of pairwise composite forecasts between each individual econometric model and the "best" futures price filter.[1/] The root mean squared errors are computed from the composite forecasts obtained by estimating

$$P_{t+h} - \bar{P} = k_1 \, (\hat{P}_{t,t+h} - \hat{\bar{P}}) + k_2 \, (\hat{f}_{t,t+h} - \hat{\bar{f}})$$

1/ The best futures filter is defined as the futures forecast with the highest rank among the first-week average, middle-week average, monthly average, and last Friday closing for the forecast comparisons made at different points in time (Tables 11 through 18).

TABLE 19

Wheat: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3
Best futures	Last Friday closing	Last Friday closing	Last Friday closing
Chase/Futures	.255 (.11, .72)	.332 (.62, .18)	.336 (.28, .07)
Doanes/Futures	.195 (-.45, .91)	.279 (-.49, .76)	.296 (-.22, .26)
DRI/Futures	.230 (-.16, 1.0)	.341 (-.08, .68)	.351 (-.16, .16)
Wharton/Futures	.251 (.35, .50)	.342 (.32, .34)	.352 (-.46, .57)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

TABLE 20

Corn: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978

Forecast horizon (quarters)	1	2	3
Best futures	Last Friday closing	First week average	First week average
Chase/Futures	.184 (-.085, .38)	.160 (-.01, -.58)	.148 (-.146, -.263)
Doanes/Futures	.149 (-.482, .733)	.141 (-.06, -.51)	.130 (-.04, -.26)
DRI/Futures	.156 (-1.11, 1.39)	.172 (.009, -.47)	.152 (-.195, -.24)
Wharton/Futures	.183 (.166, .164)	.160 (.067, -.60)	.127 (.57, -.547)

TABLE 21

Cotton: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3	4
Best futures	Last Friday closing	Middle week average	Last Friday closing	Last Friday closing
Chase/Futures	4.37 (-.41, .88)	5.65 (-.57, .59)	5.16 (-.72, .59)	5.41 (-1.02, .067)
Doanes/Futures	4.59 (-.21, .68)	6.13 (-.58, .59)	5.783 (-.081, .003)	b/
DRI/Futures	2.86 (-.04, .509)	3.02 (-.46, .66)	3.67 (-.53, .57)	1.90 (-.79, -.4)
Wharton/Futures	4.22 (-.37, .61)	5.14 (-.59, .29)	4.60 (-.62, .083)	4.51 (-.42, .24)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

b/ Blanks indicate insufficient data available to compute composite forecasts.

TABLE 22

Soybeans: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3	4
Best futures	Last Friday closing	Middle week average	First week average	First week average
Chase/Futures	.857 (-.79, 1.03)	.848 (.92, -.77)	.640 (.88, -.81)	.395 (1.25, -.044)
Doanes/Futures	.884 (-.33, .57)	.766 (.66, -.44)	.612 (.56, -.46)	.028 (.12, .19)
DRI/Futures	.866 (-1.26, 1.44)	.935 (.043, .078)	.631 (.86, -.85)	.474 (.55, .11)
Wharton/Futures	.876 (-.73, .80)	.901 (-.35, .43)	.759 (-.32, .47)	.660 (.38, .43)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

b/ Blanks indicate insufficient data available to compute composite forecasts.

TABLE 23

Soybean Meal: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3	4
Best futures	Monthly average	First week average	First week average	First week average
Chase/Futures	8.18 (.14, .36)	8.99 (-.10, .49)	8.80 (-.54, 1.23)	[b/]
DRI/Futures	29.34 (-.40, .58)	20.61 (-.36, .16)	9.16 (.28, -.72)	8.63 (.23, -.12)
Wharton/Futures	27.95 (-1.13, 1.43)	21.63 (-.11, -.11)	9.86 (-.14, -.32)	9.98 (-.086, -.071)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

b/ Blanks indicate insufficient data available to compute composite forecasts.

TABLE 24

Soybean Oil: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3	4
Best futures	Monthly average	Monthly average	First week average	First week average
Chase/Futures	1.25 (-.17, .44)	.45 (-.20, -.18)	.37 (.093, -.31)	b/
DRI/Futures	2.79 (-.43, .49)	2.54 (-.21, -.20)	2.32 (.12, -.50)	1.74 (.41, -.32)
Wharton/Futures	2.30 (-.87, .59)	2.46 (-.38, -.24)	2.14 (.59, -.80)	1.48 (.92, .31)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

b/ Blanks indicate insufficient data available to compute composite forecasts.

TABLE 25

Hogs: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3	4
Best futures	Last Friday closing	Last Friday closing	Monthly average	Middle week average
Chase/Futures	2.20 (.30, .30)	3.39 (-.039, .2)	3.04 (-.72, .37)	2.06 (-.21, .023)
Doanes/Futures	2.41 (.11, .44)	3.29 (.16, .14)	3.65 (-.095, .089)	[b/]
DRI/Futures	2.41 (.095, .43)	3.36 (.13, .087)	3.59 (.064, -.068)	2.03 (.73, -.26)
Wharton/Futures	2.32 (.18, .44)	3.39 (-.051, .18)	3.33 (-.54, .069)	1.79 (.81, .055)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

b/ Blanks indicate insufficient data available to compute composite forecasts.

TABLE 26

Live Cattle: Root Mean Squared Error of Pairwise Composite Forecasts
Econometric Models *vs.* Futures
December, 1976, Through December, 1978[a/]

Forecast horizon (quarters)	1	2	3	4
Best futures	Last Friday closing	Monthly average	Monthly average	First week average
Chase/Futures	4.45 (.45, .63)	5.98 (1.01, .30)	7.87 (.72, .14)	3.16 (-2.35, .35)
Doanes/Futures	4.66 (.04, .92)	6.02 (1.32, -.1)	5.38 (1.73, -.87)	b/
DRI/Futures	4.58 (-.13, 1.07)	6.32 (.57, .33)	6.52 (1.58, -1.01)	4.60 (1.94, -.91)
Wharton/Futures	4.58 (-.12, 1.04)	6.49 (.30, .62)	6.98 (1.83, -.51)	4.49 (1.54, -.36)

a/ Estimated weights, $\hat{k}_1$ and $\hat{k}_2$, associated with the econometric and futures price forecasts, respectively, are reported in parentheses below the root mean squared error.

b/ Blanks indicate insufficient data available to compute composite forecasts.

where P_{t+h}, $\bar{P}$, and h are as defined on page 13; $\hat{P}_{t,t+h}$ and $\bar{\hat{P}}$ refer to the econometric forecast made at time t for forecast period t + h and the mean of the econometric forecast, respectively; $\hat{f}_{t,t+h}$ and $\bar{\hat{f}}$ refer to the futures forecast made at time t for forecast period t + h and the mean of the futures forecast, respectively; and k_1 and k_2 refer to the weights on the individual forecasts in forming the composite forecasts (Appendix B). The weights, k_1 and k_2, were estimated by conventional methods (i.e., ordinary least squares).[1/] The estimated weights are reported in Tables 19 through 26 in parentheses below the estimated root mean squared errors where the first numerical value defines k_1 and the second $\hat{k}_2$.

In comparing the results for the composite forecasts in Tables 19 through 26 to the magnitudes of the root mean squared errors in Tables 3 through 10, it is clear that the composite forecasts are significantly more accurate than their individual components. In some cases the root mean squared errors for the composite forecasts are more than 50 percent less than the minimum of the root mean squared error of the econometric model and selected futures forecast (see, for example, the composite Chase/Futures root mean squared error for the one-quarter soybean oil price forecast). These marked improvements are not entirely surprising since the composite forecasts

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1/ Note that the constraint, $k_1 + k_2 = 1$, was not imposed in the estimated composite regressions. As shown in Appendix B, this constraint follows if both individual forecasts forming the composite are unbiased. Since available evidence strongly suggests that neither $\hat{P}_{t,t+h}$ or $\hat{f}_{t,t+h}$ are unbiased and that the magnitude of their associated biases are not constant over the sample period, such a constraint is apparently inappropriate. It should also be noted that, if one or more of the individual forecasts is biased, an errors-in-variables estimation of k_1 and k_2 would generate a more favorable (lower) root mean squared error than an ordinary least-squares estimation of k_1 and k_2. The empirical differences between these two estimation procedures will be explored in our further research on the topic of composite commodity price forecasting.

and the associated root mean squared errors were computed from the sample forecasts and thus are not determined in the same ex post sense as the root mean squared errors in Tables 3 through 10. Of course, computation of the root mean squared errors from data outside the composite forecast estimation period would be preferable. But, unfortunately, such data were not available. In any event, the evidence in Tables 19 through 26 appears to support the view that composite forecasting is a worthwhile exercise. Moreover, in the case of commodity price forecasting, this evidence suggests that econometric and futures forecasts contain independent information which may be valuably combined in a composite.

Nevertheless, the weights attached to the econometric and futures forecasts exhibit very little regularity over the various commodities and forecast horizons. In the case of wheat, for example, the weight attached to the Chase and Wharton forecasts are positive while the weights attached to the Doanes and DRI forecasts are negative.[1/] For soybeans, the weights on all the econometric forecasts are negative for the first quarter, while for other horizons all forecasts are positive except for the Wharton forecasts of two and three quarters. For corn, the weights are generally negative while for wheat cotton, hogs, and cattle, they are generally positve.

In general, the absolute weights attached to the futures forecasts tend to decline with the forecast horizon. This reflects a declining relative accuracy of futures price forecasts to the econometric price forecasts as the forecast

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1/ For many, but not all cases (especially soybeans), the estimated negative weight is insignificant at the conventional 95 percent confidence level. As noted in Appendix B, an inferior forecast may merit inclusion in the composite with a negative weight if its errors are compensated by their correlation with the errors of the other forecast.

horizon gets longer. When the relative accuracy of one forecast deteriorates with the forecast horizon, its associated weight in the composite forecast falls. The most striking illustration of this observation is provided by soybeans and cattle. For both of these commodities, the futures price forecast is given the largest weight for the first quarter, while for the second and third quarters the outcomes are dramatically reversed. For the latter forecast horizons, the largest weights by far are attached to the econometric forecasts in most cases.

In contrast to the results in Tables 3 through 10, the composite forecast accuracy is not as sensitive to horizon length as the individual forecasts. The composite forecast accuracy improves substantially with the horizon length for several commodities (corn, soybeans, soybean meal, and soybean oil), whereas this was the case only with soybeans in the individual forecasts. This property may reflect the degree of information independence between econometric and futures market forecasts across horizon length. For the one-quarter horizon, there is certainly less independence than for the longer term horizons. The econometric forecasters often adjust their forecasts in accordance with the discrepancy between their most recent forecast and spot prices. To the extent that year-term future contract price variations are closely related to current spot prices, there is thus a closer correspondence among the two types of forecasts for a one-quarter horizon than for far longer term horizons.

IX. Summary and Conclusions

The results of this paper may be summarized by returning to the questions raised in the introduction. Are futures markets more or less accurate than the econometrically based forecasts? The evidence is not overwhelmingly in

favor of either. However, the results, as a whole, suggest surprising accuracy in the futures market prices as forecasters as compared with the econometric forecasts. Futures market prices seem to be a clear favorite for soybean oil and meal. On the other hand, some of the econometric forecasts seem to be preferable for livestock commodities while results for other commodities are mixed.

Does the absolute and comparative accuracy depend upon the forecast horizon? Is the relative and absolute forecast accuracy commodity dependent? The effect of forecast horizon on absolute forecast accuracy apparently depends to a large extent on characteristics of individual markets. For active and fluctuating markets such as soybeans, the longer term forecasts are more accurate than short horizon forecasts. For more stable markets such as wheat and hogs, on the other hand, absolute accuracy decreases dramatically with forecast horizon. Examining relative accuracy, there are also some striking differences among commodities. For the livestock commodities, the accuracy of econometric forecasts relative to futures market prices seem to clearly improve with the time horizon of the forecast as we would expect. The fact that these trends are not apparent for the grain markets may reflect greater (relative) availability of information in the futures trading of grains. This result is perhaps associated with more inelastic short-term supply response and more accurate estimates of acreages than of cattle numbers. The fact that econometric forecasts do not dominate futures market prices for any of the existing contract horizons thus seems to indicate that positive social benefits may be forthcoming from trading of longer horizon futures contracts. This conclusion is underscored when one considers the benefits from composite forecasting.

What improvements in forecasting accuracy can be achieved by formally combining futures markets and commercial econometric forecasts? Our results suggest that the improvements in accuracy can be dramatic. In some cases the performance of the composite forecast is more than 50 percent better than the best individual forecast. Hence, the evidence presented in Section VIII demonstrates that econometric and futures market forecasts contain enough independent information so that they may be valuably combined.

Although the weights in the composite forecasts attached to individual forecasts exhibited little regularity over econometric forecasts, commodities, and forecast horizons, some interesting results were obtained including the general decline in relative weights attached to the futures forecasts vis-a-vis econometric forecasts as the horizon length expands and the relative insensitivity of composite forecast performance to horizon length vis-a-vis individual forecasts.

Of course, before the results presented in this paper on the composite forecasts are operationalized in an actual decision context, much remains to be accomplished. In particular, there will always be uncertainty concerning the value of the combination weights. This can be treated by time-varying parameter schemes which are conditional on the performance of individual forecasters. Second, additional evaluations should be performed outside the composite sample estimation period to assess performance in a truly ex post sense. Third, composite estimation procedures can be easily developed which are superior to ordinary least squares. Such procedures, in addition to "errors in variables" formulations, might involve formal models for the "basis" determination as well as the magnitude of the bias and its changing structure over the forecast horizon for both econometric and futures market

forecasts. Fourth, once the above three tasks are completed, the results should be integrated with risk management frameworks (e.g., decision support systems) to assess the real value of information provided by composite commodity price forecasting.1/

1/ Of course, in any case, these frameworks or decision support systems should be viewed as an aid to experience and sound judgment, never a substitute for such valuable characteristics.

Appendix A

The price series forecasted by the econometric firms considered in this study are as follows:

Wheat: Chase and Wharton—No. 1 Hard Red Winter wheat, Kansas City (dollars per bushel).

Doanes—Average price received by farmers, United States (dollars per bushel).

DRI—Average of Kansas City, Minneapolis, Portland, and St. Louis prices (dollars per bushel).

Corn: Chase, DRI, and Wharton—No. 2 Yellow corn, Chicago (dollars per bushel).

Doanes—Average price received by farmers, United States (dollars per bushel).

Cotton: Chase, Doanes, and Wharton—Average price received by farmers, United States (cents per pound).

DRI—Upland cotton lint price, U. S. Department of Agriculture (cents per pound).

Soybeans: Chase, DRI, and Wharton—No. 1 Yellow soybean price, Chicago (dollars per bushel).

Doanes—Average price received by farmers, United States (dollars per bushel).

Soybean meal: Chase, DRI, and Wharton—Bulk, 44 percent protein price, Decatur (dollars per ton).

Soybean oil: Chase, DRI, and Wharton—Crude tank f.o.b. price, Decatur (cents per pound).

Hogs: Chase, Doanes, DRI, and Wharton—7-market average price, barrows and gilts (dollars per hundredweight).

Live cattle: Chase, Doanes, DRI, and Wharton—Choice 1,100-1,300 pounds slaughter steer price, Omaha (dollars per hundredweight).

Appendix B: Composite Forecasting

The composite forecasting approach has been available in the literature for over 10 years (Barnard; Bates and Granger; Granger and Newbold; Newbold and Granger; Johnson and Rausser). To motivate the approach, assume two forecasts, $\hat{p}_t^1$ and $\hat{p}_t^2$, of p_t are available. Assume initially the two forecasts are unbiased and are bivariate normal. In particular, the errors of the forecasts,

$$(1) \qquad \hat{\xi}_t^1 = p_t - \hat{p}_t^1 \qquad \text{and} \qquad \hat{\xi}_t^2 = p_t - \hat{p}_t^2,$$

are distributed as

$$(2) \qquad \begin{pmatrix} \hat{\xi}_t^1 \\ \hat{\xi}_t^2 \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix}\right].$$

The combined forecast is simply the weighted average of the two simple forecasts, i.e.,

$$(3) \qquad \hat{p}_t^c = k\hat{p}_t^1 + (1 - k)\,\hat{p}_t^2.$$

In general, k will be in the unit interval if the forecasts are unbiased.

Presuming the individual forecasts are unbiased, it follows that $E(\hat{p}_n^c) = p_n$. The variance σ_c^2 is computed directly using the distributional assumptions in (2), i.e.,

$$(4) \qquad \sigma_c^2 = k^2\sigma_1^2 + (1 - k)^2\sigma_2^2 + 2k\,(1 - k)\,\rho\sigma_1\sigma_2.$$

The value for k, which minimizes this forecast variance, is

$$k_0 = \frac{\sigma_2^2 - \rho\sigma_1\,\sigma_2}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\,\sigma_2}. \tag{5}$$

Substituting k_0 from equation (5) into (4) gives the expression for the variance-minimizing composite forecast,

$$\sigma_{c_o}^2 = \frac{\sigma_1^2\,\sigma_2^2\,(1 - \rho^2)}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\,\sigma_2}. \tag{6}$$

The denominator for equation (6) is the variance of the difference in forecasts, $\hat{p}_t^1$ and $\hat{p}_t^2$. In general, the composite forecast variance σ_c^2 will be smaller than the minimum of the variances of the individaul forecasts. The special cases are $\rho = \sigma_1/\sigma_2$ or $\rho = \sigma_2/\sigma_1$. For these special cases, the optimizing composite forecast variance is equal to the minimum of the variances of the individual forecasts. It is this result, equation (6), that is the basis for claims that composite forecasts will be at least as good as the individual forecasts.

A number of additional specialized results follow from equations (5) and (6). First, the denominator for (5) is always positive so that the sign of k_0 is determined by the numerator. Specifically, it can be easily shown that the sign of k_0 is determined by whether $\sigma_2/\sigma_1 \gtrless \rho$. Usually the value for k would be constrained to be positive. The fact that a negative k is admitted and perhaps optimal is of interest. An inferior forecast may merit inclusion with a negative weight <u>if</u> the high error variance is compensated for by ρ, that is, if the parts unexplained by the two forecasts are closely related.

On the basis of the above framework, a number of additional results can be obtained, including the sensitivity of $\sigma^2_{c^o}$ to ρ, alternative estimation procedures for k (especially for small samples), any finite number of individual forecasts, and the treatment of conditional forecasts. For further details, see Johnson and Rausser. Of immediate concern for the present analysis is the case of biased individual forecasts. That is, the futures market and/or the econometric models investigated here may generate biased forecasts.

For the case of one or more individual biased forecasts, let

$$(7) \qquad E\,(p_t - \hat{p}_t^1) = \delta_{t1} \qquad \text{and} \qquad E\,(p_t - \hat{p}_t^2) = \delta_{t2}.$$

The mean squared error of the combined forecast under this circumstance is

$$(8) \qquad \begin{aligned} \sigma^2_{mc} &= k^2\,\sigma_1^2 + (1-k)^2\,\sigma_2^2 + 2k\,(1-k)\,\rho\sigma_1\,\sigma_2 \\ &\quad + k^2\,\delta_{t1}^2 + (1-k)^2\,\delta_{t1}^2 + 2k\,(1-k)\,\delta_{t1}\,\delta_{t2}. \end{aligned}$$

The mean squared minimizing value for k is now given by

$$(9) \qquad k_{t^o} = \frac{\sigma_2^2 - \rho\sigma_1\,\sigma_2 + \delta_{t2}^2 + \delta_{t1}\,\delta_{t2}}{\sigma_1^2 + \sigma_2^2 - 2\rho\sigma_1\,\sigma_2 + \delta_{t1}^2 + \delta_{t2}^2 - 2\delta_{t1}\,\delta_{t2}}.$$

Note that, if just one of the forecasts is biased, say $\delta_{t2} = 0$, then k_{t^o} is the same as k_0 except for the additional term in the denominator δ_{t1}. This additional term has the effect of lowering k_{t^o} and thus ceteris paribus increasing the weight on $\hat{p}_t^2$ in the composite forecast.

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