Price Forecasting and Hedging to Enhance
Prices and Reduce Risk

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In recent years, most of the studies which have developed models for forecasting hog prices and/or production have employed various statistical measures to validate the models and evaluate their forecasting performance (Arzac and Wilkinson; Brandt and Bessler (1981); Dixon and Martin; Freebairn and Rausser; Heien). However, very little attention has been given to the usefulness of the information generated by these forecasting models for decision making. A separate group of studies has concentrated on the development of hedging strategies for hog producers (Campbell; Leuthold and Peterson; McCoy, Price, and Solomon). Most of the hedging strategies used in these studies are based on futures market/cash price or futures price/breakeven cost criteria. None incorporates current information regarding future cash price levels into a hedging framework and hedging effectiveness is evaluated with a mean-variance analysis of returns.

In an optimal hedging study for egg producers, Peck adopted a slightly different view of risk. She asserted that in many instances distant futures prices are nearly as variable as cash prices, implying that risk reduction from hedging may be rather low. Peck felt that if producers make decisions on the basis of price expectations, then the important measure of risk is the "unexplainable" variation in prices. She thus contrasted the root mean squared error (RMSE) of the forecast series as a measure of risk with the traditional risk measure, the standard error of the price or profit series.

In this paper, a theoretical framework is developed which illustrates how a producer could incorporate price forecasting with hedging to reduce risk and increase expected returns. Several forecasting models are used to predict monthly cash hog prices and the forecasts from these models are combined with a simple hedging strategy for a hog producer. In contrast with the above hedging studies, the hedging decision in this study is treated as a dynamic activity which encompasses the entire farrow-to-finish process. The various hedging forecasting approaches are then evaluated in terms of mean prices and risk reduction, where risk is viewed as the unexplainable variation in prices. A final feature of this paper is a comparison of the economic performance of the forecasting models with their statistical performance.

Conceptual Behavior of a Risk Averse Producer

Von Neumann and Morgenstern hypothesized that if a risk averse individual is faced with two alternatives, both with the same expected outcome, the individual would choose the option with the lower variability (risk) to maximize expected utility. Ikerd used this framework to show that a risk-averse producer may take a guaranteed forward price which is lower than the expected cash price. The producer is assumed to have a utility function U = U(P), where P is the product price. Risk aversion is reflected by the concavity of the utility function (Figure 1). If a producer has a subjective discrete probability distribution of expected prices and assigns equal probabilities that either a or b will be the price received when no forward pricing is considered, the expected price of this distribution is P and the expected utility is U.

If forward pricing is used the final price will be known with greater but not complete certainty, represented by the distribution a'b' in Figure 1. The expected price from forward pricing is also P, however, the expected utility is U', which is greater than the expected utility from cash sales (U).

Ikerd noted that the producer would prefer any guaranteed price above P to cash marketing because this action would result in the same (or higher) expected utility.

Ikerd felt that selective hedging may be of limited value to producers, unless they had a comparative advantage in bearing price risks. Brandt argued that a "student of the market", who has regular access to market information, may well have an advantage in dealing with price risks. By combining price forecasts with hedging, a producer could potentially obtain even higher levels of expected utility and price.

A simple hedging strategy is proposed which has the producer selling futures contracts when the current price forecast is below the localized futures quote for some deferred contract month. Otherwise, the producer remains unhedged in anticipation of receiving the higher (forecast) cash price. In Figure 1, this would raise the lower end of the producer's expected forward price distribution from a' to (say) a''. At the same time, the producer retains the flexibility to receive the maximum expected cash price (b) by remaining unhedged when conditions dictate.

By assigning equal probabilities to the endpoints a''b, the expected price from selective hedging becomes P'' and the expected utility is U''. In fact, the selective hedging strategy will result in higher expected utility than cash marketing over the entire range of outcomes (a''b). Selective hedging will also result in higher expected utility than routine forward pricing over the range a''b''.

The theoretical possibility also exists that the hedging-price forecasting strategy could result in lower risk (as measured by price distribution) than the other two options. Clearly, in Figure 1 the selective hedging range (a''b) is smaller than the cash marketing range (a b), indicating less risk. Selective hedging also results in lower risk than routine forward pricing if the distance between a'a'' is greater than the distance between b'b, which is expected to be relatively small. The more accurate the signals from price forecasting, the greater will be the a'a'' range.

Alternative Forecasting Procedures

A variety of methods are currently used for making agricultural forecasts. The amount of complexity ranges from large-scale econmetric models (see Just and Rausser; Green and Hoskin), which simultaneously forecast prices and quantities for a number of commodities, to single equation models designed to forecast the value of a single variable. Another forecasting method is the class of autoregressive integrated moving average (ARIMA) processes (Oliveria, O'Connor, and Smith; Spriggs). ARIMA processes are based entirely on the past behavior of the economic variable in question. Brandt and Bessler (1981) and Kulshreshtha, Spriggs, and Akinfemiwa have examined the feasibility of generating composite forecasts by combining the results of several individual forecasting models.

In this study, several types of monthly forecasting models were constructed, including two single-equation econometric models, an ARIMA model, a seasonal index, and several simple-average composite forecasts. The initial estimation period was from March 1965 through November 1976. With the exception of the seasonal index, the models were periodically re-estimated through 1982. All models were designed to forecast seven-market prices of barrows and gilts over a two-to-ten month horizon. The forecasts were updated quarterly following the release of each _Hogs and Pigs_ report (HPR). (See Holt for a complete presentation of the estimation results of the forecasting models.)

Two specificatons of the econometric model were used: a linear and a curvilinear (double log) form. Both specifications included three equations. The first equation used the weight categories from the HPR to forecast hog prices two through four months out. The second equation incorporated second sow farrowing intentions in place of weight categories to forecast prices five to seven months out. The third equation used first sow farrowing intentions to forecast prices eight through ten months into the futue. Other variables in the econometric models included the hog-corn ratio (lagged 24 months), consumer disposable income (lagged 11 months), and eleven monthly dummy variables to allow for seasonality in hog prices.

Due to the presence of serial correlation among the residuals, the econometric models were estimated with the Cochrane-Orcutt iterative procedure. The economic variables had the correct theoretical signs in all cases and the estimated coefficients were generally large relative to their standard errors. Both the linear and curvilinear models had reasonably high R^2s over the fit period (.95 or above).

An ARIMA process for the monthly hog price series was also identified, estimated, and checked. The specification included first and eleventh order regular moving average parameters, in addition to a twelfth order seasonal moving average parameter. All estimated coefficients were significant at the 95 percent level and an R^2 of .95 indicated a good fit. The Q-statistic was below the critical chi-squared value, indicating the residuals followed a white noise process.

A monthly index of hog prices was also constructed and used for forecasting. The index values suggest that hog prices are seasonally higher during the summer and lower during the spring (March and April) and fall (November). To generate a forecast with the index, the three most recent monthly cash prices are averaged and seasonally adjusted. This adjusted average is then multiplied by the desired monthly index value to generate a price forecast.

The final forecasting procedure involves the simple-average composite of several individual forecasts. Two separate composite forecast series were constructed by averaging the linear econometric and ARIMA forecasts, and the curvilinear econometric and ARIMA forecasts.

Statistical Evaluation of Forecasts

Monthly cash price forecasts were generated over the 24-quarter period from December 1976 through September 1982. The RMSEs of the forecasts generated by each model are presented in Table 1. The curvilinear econometic forecasts tended to have lower RMSEs than any other individual forecasting approach (linear econometric, ARIMA, and seasonal index). The ARIMA forecasts had the highest RMSEs during seven of the nine forecast periods, while the seasonal index performed only slightly better.

The two composite forecasts, particularly the ARIMA curvilinear econometric composite, clearly resulted in the lowest forecast errors (Table 1). The ARIMA curvilinear econometric composite had lower RMSEs than either of its individual components during eight forecast periods. The ARIMA linear econometric composite had similar results.

The standard errors of the various forecast series are also presented in Table 1. The standard errors exhibit the same general tendencies as the RMSEs and compare quite closely with the standard deviations of the cash price series.

The Hedging Model and Results

The hedging model is based on a hypothetical farrow-to-finish operation.

The hedging strategy used in this analysis was nearly identical to the one outlined in the theoretical section. Futures contracts are sold when the price forecast for some future month is below the localized futures quote for that same month. (The futures price is localized by subtracting the most recent three-year average of the actual basis for the same delivery month from the current futures price.) If the price forecast is above the current localized futures price, the producer remains unhedged. All hedges are placed at the average of closing prices for the first five trading days following release of the HPR. All positions carried to maturity are closed at the average of the first five trading days of that month.

A unique feature of this study was the dynamic nature of the hedging strategy. Because of the approximate ten-month period between breeding and slaughter, the producer had three opportunities to establish or liquidate a futures position. The three opportunities occur at breeding, farrowing, and during the growing stage for each group of market hogs. (See Holt and Brandt for a more complete discussion of the dynamic characteristics of the model and the results.)

All trades were executed at a roundturn commission cost of $60 per contract. Interest was charged on an initial $600 margin requirement (per contract) at an annual rate of 12 percent. Margin calls were not considered since in an on-going hedging program, they would tend to be cancelled by trading account surpluses.

The hedging model was operated over the same period used to make the out-of-sample forecasts. The results of the six hedging forecasting approaches are also presented (in parentheses) in Table 1. For comparison, a routine hedging strategy is included. Among the six approaches, only the econometric models resulted in mean prices which were lower than the average cash price.

The seasonal index was associated with the highest average price, as well as the largest number of trades. The ARIMA forecasts triggered the second largest number of futures transactions and had the third highest average price. The ARIMA linear econometric composite was associated with the second highest average cash price while the ARIMA curvilinear composite tied with cash marketing. The routine hedging strategy resulted in the lowest average price among all alternatives.

A statistical test, similar to the test suggested by Peterson and Leuthold, was used to determine if the mean hedging prices were significantly different from the average cash price. The results indicated that the linear econometric selective hedging strategy and the routine hedging strategy had mean prices which were significantly less than the mean cash price, at the 90 percent level of confidence.

Risk reduction is the other important consideration in any hedging program. Previously it was argued that if producers react on the basis of price expectations, then risk should be associated with the predictive accuracy of those expectations (RMSE). If hedging occurs, the only remaining uncertainty about the price is associated with the basis forecast error. Thus for each period when a hedge is placed, the price forecast error is replaced with the basis forecast error for computation of a hedging RMSE series.

In the above manner, hedging RMSEs were calculated for each hedging forecasting approach (Table 1). In all instances, the hedging RMSEs (in parenthesis) are directly comparable with the original forecast RMSEs. With only one exception (curvilinear econometric, month 9), hedging resulted in a reduction of unexplainable price variation. The greatest risk reduction also tended to be associated with the more profitable trading approaches (e.g., the seasonal index and ARIMA models) since these models generated the most trading activity.

The standard errors of the hedge series calculated on the basis of the cash price plus any futures profit or loss per cwt. are also reported in Table 1. These standard errors are equivalent to the measure of risk that has been used in most of the aforementioned hedging studies (for another example of this type, see Brandt and Bessler, 1983). The important comparison is that in nearly every case, the standard derivations for each hedging forecasting series were larger than the same standard deviations for either the original forecast or cash price series. It is quite obvious that the measure of risk used to evaluate a hedging scheme is an important consideration. In fact, if the standard error had been used as the risk measure in this study, the conclusion would be that all of the hedging forecasting approaches were inferior to cash marketing (e.g., essentially the same level of profits with higher risk). By using an alternative (and perhaps more appropriate) definition of risk as the unexplainable variation in prices, we have shown that all of these hedging forecasting alternatives were capable of reducing price uncertainty.

Conclusions

The empirical results of this study lend support to the hypothesis that combining price forecasting with hedging can reduce risk and, perhaps, increase expected price for the producer. Four of the six hedging forecasting approaches resulted in mean prices which were higher than the average cash price, although none of the differences was statistically larger. At the same time, all six hedging forecasting combinations were capable of reducing unexplainable price variaton (risk) for the producer.

The final implication of this study is that agricultural model builders should not rely entirely on statistical measures to evaluate their models. While, in general, models which display good statistical forecasting performance can be expected to also have reasonable economic performance, there need not be an exact correspondence. In the future, agricultural economists should consider other alternatives, perhaps similar to the framework used here, to evaluate the performance of their forecasting models.

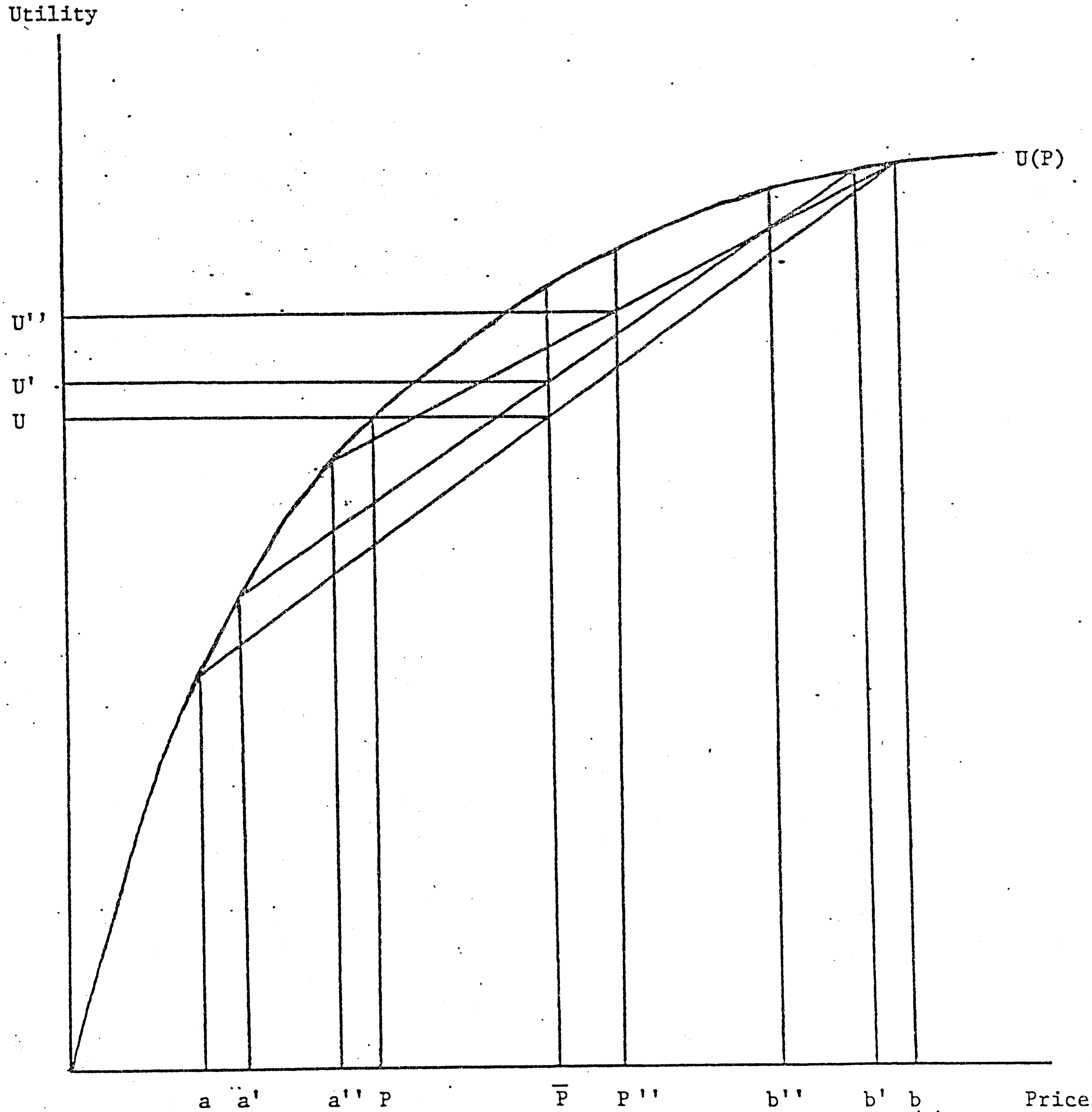

Figure 1. Expected Utility From Cash Sales, Forward Pricing, and a Selective Hedging Strategy for a Risk Averse Producer.

Table 1. Evaluation Measures of the Forecasting and Hedging Approaches, February 1977 - January 1983.

	Forecast Horizon[a]									Mean Price
	2	3	4	5	6	7	8	9	10	
					($/cwt.)					
Root Mean Squared Errors										
1. Linear Econometric	6.11[b]	6.29	7.27	8.41	7.98	8.25	8.52	8.44	9.43	
	(5.73)[c]	(5.93)	(6.57)	(7.73)	(7.31)	(7.82)	(8.10)	(8.33)	(9.34)	
2. Curvilinear Econometric	6.03	5.96	6.59	7.95	7.59	8.12	8.32	8.17	9.28	
	(5.89)	(5.65)	(5.86)	(7.26)	(7.33)	(8.00)	(8.03)	(8.20)	(9.24)	
3. ARIMA	5.87	6.69	7.83	8.52	8.08	8.20	8.81	8.94	9.92	
	(4.25)	(4.98)	(6.33)	(6.47)	(6.62)	(7.14)	(7.64)	(8.25)	(9.02)	
4. Seasonal Index	6.84	6.65	7.58	8.38	7.82	8.07	8.57	8.57	9.51	
	(4.76)	(4.90)	(6.13)	(6.62)	(6.38)	(7.12)	(7.46)	(6.95)	(7.86)	
5. ARIMA - Linear Econometric Composite	5.61	6.15	7.21	8.13	7.65	7.82	8.27	8.25	9.26	
	(4.88)	(4.94)	(5.96)	(6.60)	(6.33)	(7.22)	(7.41)	(7.73)	(8.85)	
6. ARIMA - Curvilinear Econometric Composite	5.43	5.85	6.79	7.75	7.30	7.62	8.01	7.97	9.04	
	(4.81)	(4.83)	(5.65)	(6.79)	(6.56)	(7.29)	(7.52)	(7.65)	(8.79)	
Standard Errors										
1. Linear Econometric	6.55	6.52	6.77	6.46	6.05	6.24	5.96	6.07	6.63	
	(8.21)	(7.90)	(8.21)	(8.33)	(7.90)	(8.20)	(8.49)	(8.07)	(8.39)	45.26(6)[d]*
2. Curvilinear Econometric	6.29	5.50	5.90	6.03	5.43	6.14	5.86	5.31	6.07	
	(8.32)	(7.09)	(8.01)	(8.42)	(7.08)	(7.96)	(8.56)	(7.24)	(8.15)	45.44(5)
3. ARIMA	7.56	7.56	7.77	7.21	7.36	7.66	7.10	7.20	7.58	
	(7.54)	(7.27)	(7.68)	(7.60)	(7.24)	(7.60)	(7.72)	(7.40)	(7.78)	45.74(3)
4. Seasonal Index	7.54	6.99	7.46	6.89	6.52	6.71	6.13	5.53	5.63	
	(7.64)	(7.89)	(8.08)	(7.64)	(7.86)	(7.93)	(7.73)	(8.04)	(8.11)	45.95(1)
5. ARIMA - Linear Econometric Composite	6.90	6.85	7.04	6.59	6.43	6.71	6.22	6.28	6.73	
	(7.74)	(7.10)	(7.47)	(7.81)	(7.05)	(7.38)	(7.94)	(7.20)	(7.55)	45.81(2)
6. ARIMA - Curvilinear Econometric Composite	6.57	6.20	6.48	6.21	5.96	6.49	5.99	5.76	6.29	
	(7.82)	(7.25)	(7.54)	(7.91)	(7.21)	(7.46)	(8.05)	(7.37)	(7.56)	45.62(4)
7. Routine Hedge	(6.26)	(6.74)	(6.73)	(6.34)	(6.80)	(6.70)	(6.13)	(6.76)	(6.64)	42.64(7)*
8. Cash Price Series	7.43	7.25	7.47	7.50	7.20	7.41	7.62	7.36	7.59	45.62(4)

a The horizon represents the number of months following the release of the HPR.

b These numbers represent the root mean square error (top of table) and standard errors (bottom of table) for the original or forecast series.

c The numbers in parentheses represent the root mean squared error (top of table) and standard errors (bottom of table) for the hedge series.

d The numbers in parentheses beside the mean price represent the relative ranking.

* Represents significant difference from mean price for cash marketing at the 90 percent confidence level.

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