FORECASTING PRICE MOVEMENTS: AN APPLICATION OF DISCRIMINANT ANALYSIS*

by

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Abstract

The purpose of this paper is to demonstrate a technique, discriminant analysis, which might be useful in predicting the direction of movement of fall feeder calf prices to spring yearling prices. The discriminant analysis approach is then compared to regression in predicting the direction of price movement. Finally, the usefulness of incorporating the direction of price movement as a variable in a price prediction model is evaluated. Results suggest that the discriminant analysis approach and the prediction and use of the direction of price movement as a variable in forecasting models provides useful information and improves forecasts.

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Economists are often somewhat reluctant to conduct research in the forecasting area, particularly in the development of forecasting models. To confirm this, Haidacher in 1970 examined the 28 most recent issues of the American Journal of Agricultural Economics and found that only 5 of 41 price analysis articles identified forecasting as an initial objective. In a comparison of the accuracy of livestock price forecasting using simple techniques, forward pricing and outlook information, Helmers and Held conclude that more research emphasis could well be placed on the testing and development of commodity price projection models for agriculture. Since price expectations are critical to producer decisions, providing outlook information remains an important function of agricultural economists. Additional input, provided by quantitative means and tempered by subjective review, should improve forecasts of economic variables.

There appears to be no consensus on the "best" forecasting technique. Two general forecasting approaches used by agricultural economists are: (1) the models presented by Box and Jenkins, which include the autoregressive-integrated moving-average (ARIMA) forecasting models, and (2) economic models. The ARIMA models were employed by Oliveira, *et al*. to forecast beef prices. Economic models have recently been used by Agriculture Canada (1978a, 1978b) in their forecasting efforts and have traditionally received the most attention by agricultural economists.

A comparison of the forecasting abilities of these two approaches reveals that the economic model approach is usually more accurate and allows for the possible explanation of poor forecasts (Bechter and Turner; Leuthold, *et al*.

and Naylor, et al.). If the system under investigation is dynamic in the sense that the structure changes, non-casual models, such as Box-Jenkins type models, are less likely to handle such shocks than are economic models. This suggests that contributions to the forecasting area might best employ the economic model approach.

Purpose

The purpose of this paper is to demonstrate the usefulness of modifying the economic model approach to include a forecast of the direction of movement in an economic variable, namely price. From the standpoint of producer decision-making the direction of price movement alone can be useful information. Given that most economic data exhibit positive serial correlation, it is relatively easy to predict a continuation of time series movements. However, the development of a forecasting model which has the ability to identify turning points offers a greater challenge.

Specifically, this paper demonstrates a technique, discriminant analysis, which might be useful in predicting the direction of movement of fall feeder calf prices to spring yearling prices. The discriminant analysis approach is then compared to regression in predicting the direction of price movement. Finally, the usefulness of incorporating the direction of price movement as a variable in a price prediction model is evaluated. Thus, the forecasting approach outlined below explicitly recognizes that price is made up of two components, magnitude and direction.

Problem and Approach

One decision facing feeder calf producers is whether to sell spring calves in the fall or to hold these animals until the following spring. A rancher wishing to determine the optimal time for marketing cattle needs to have knowledge about the physical production response of livestock as well as price outlook, and to estimate returns and construct budgets which consider these two factors along with various direct and opportunity costs (Kearl, p. 11).

With respect to price, knowledge of the direction of its movement between fall and spring (calves to yearlings) may be useful. In fact, economists are often initially more concerned about the direction of price movement than about magnitude, e.g., in a cursory review of supply and demand. To accurately construct budgets, the rancher will of course eventually need information on price magnitude as well. The approach here is to develop a model which can predict the direction of price movement between fall and spring feeder animals, and then use this information in a model to predict magnitude.

The Model

The intent of the model is to classify price movements into one of two mutually exclusive classes: increase (up) or decrease (down). The discriminant analysis approach has the capability of such delineation inasmuch as its objective is to classify individuals, objects or phenomena into one of two or more mutually exclusive categories or classes on the basis of a set of independent variables. This discrimination is accomplished by combining the set of independent variables into a linear function or index in such a manner that the difference between the means of the index for the mutually exclusive categories per unit of dispersion about the means is maximized (Duncan and Leistritz, p. 5).[1/]

Since the discriminant model can be used as a type of economic model, the selection of discriminating variables is analogous to the selection of independent variables for a multiple regression model. An identification of variables consistent with economic theory would appear to be one strength of this procedure relative to autoregressive techniques, spectral analysis and harmonic motion analysis. Thus, economic variables which should more accurately reflect the movement of a specific economic variable are used as the independent variables, in discriminant analysis, rather than past observations of the dependent variable, trigonometric functions or moving averages.

The following model is used to classify the direction of price movement between October feeder calf prices and the succeeding March yearling prices. Since the objective of the model is forecasting, it is specified in an ex post manner, and predicts the direction of movement in March prices in October or as soon as selected September price series are available. The model is: $Z_t = B_0 + B_1X_{1t} + B_2X_{2t} + B_3X_{3t} + B_4X_{4t} + B_5X_{5t}$. Where Z_t = the discriminant score used in categorizing the direction of movement (up or down) in the price of October feeder calf prices in year t as compared to the March price of yearlings in year t + 1 and B_i = the discriminant or weighting coefficient for the i^{th} variable. The X_i's are specifically defined as: X_1 = yearling price in September deflated; X_2 = direction of movement in yearling prices between March and September in year t (1 if up and 0 if down); X_3 = price of September slaughter steers deflated; X_4 = price of September corn deflated; and X_5 = percent of January 1 inventory slaughtered.

Prices of feeder calves (cattle) are derived from the prices of slaughter cattle (X_3) and the costs of feeding these animals to slaughter weight, primarily the cost of grain (X_4). Subsequent prices may also depend on the direction of price movement (Kearl, p. 8). This is represented by X_2 in the above model. The September yearling price (X_1) acts as a positioning variable and X_5 depicts liquidation and expansion periods in cattle inventories. This latter variable may also serve as a proxy for changes in the quantity of feeder calves, where the quantity of feeder calves is affected by the proportions of cows and potential herd replacement animals which are slaughtered.

The above model should serve to demonstrate the technique of predicting the direction of price movement and of using this information to predict the magnitude of price. For comparative purposes, a regression model containing the same independent variables as the discriminant model was also estimated. The dependent variable was redefined as the March yearling price in year t + 1 deflated minus the October feeder calf price in year t deflated.

Data

Sources of data included selected issues of the U.S.D.A. publications Livestock and Meat Situation, Livestock and Meat Statistics and Agricultural Statistics. Corn prices were obtained from selected issues of the Commodity Year Book. Data for the period 1925-1969 were used to estimate the model. Data for the years 1970-1978 were reserved to test the forecasting ability of the model. During the period 1925-1969 there were 24 instances where the October price of good and choice feeder calves at Kansas City was greater than the next year's weighted average of all weights and grades of March feeder steer price. The movement in yearling prices (X_2) was calculated using March and September yearling prices of the same year. Corn price is the September 15 average price received by U.S. farmers. The slaughter price is represented by the average cost per 100 lbs. of sales out of first hands for choice slaughter steers at Chicago, 1925-1949. For the period 1950-1978 this price is represented by the price of choice slaughter steers at Omaha, average cost per 100 lbs. live weight of sales out of first hands and more recently 900-1100 lbs. Percent of January 1 cattle and calf inventory slaughtered was calculated using the sum of cattle and calf commercial slaughter.

One problem which must be dealt with in a forecasting model is the range of the sample data relative to the range of the validation and future data. Variables which are subject to inflation may move rapidly beyond the range of the data over which the model is estimated. To adjust for inflationary trends, price data were deflated using the consumer price index.

Results

The results of the estimated discriminant and regression models are presented in Table 1. In the discriminant model, the standardized coefficients identify the

Table 1. Estimated Results for the Discriminant and Regression Models.

Variable	Discriminant Coefficients		Regression Coefficients	
	Standardized[a]	Unstandardized	Standardized	Unstandardized
Constant	----	-8.269	----	-13.060 (-3.404)[b]
X_1	-0.431	-0.0624	-0.508	-0.625 (-2.124)
X_2	0.169	0.388	0.257	2.152 (2.489)
X_3	0.0324	0.00459	-0.0980	-0.0502 (-0.357)
X_4	0.290	0.519	0.387	2.500 (2.640)
X_5	0.826	0.242	0.415	0.438 (3.860)
				R^2 = 0.62
				F = 12.772

[a] Standardized by the measurement scales and variability in the original data.

[b] Numbers in parenthesis are t statistics.

relative importance of the independent or discriminating variables in explaining the dependent variable. Of the five variables in the model, percent inventory slaughtered (X_5) is the most powerful discriminating variable, followed by the September yearling price (X_1), September corn price (X_4), direction of movement in yearly prices between March and September (X_2) and September slaughter steer price. The regression model predicting the deflated difference between March (year t + 1) and October (year t) feeder prices is generally consistent relative to signs with the discriminant model, with the exception of the slaughter price variable. In terms of relative magnitudes of the standardized coefficients, the two models are generally comparable.

In the discriminant model, the unstandardized discriminant coefficients can be used to predict the type of price movement, i.e., up or down. Upon inserting values for the discriminating variables for year t, Z_t can be calculated. The classification procedure is as follows (Johnson, p. 339):

If $Z_t > Z_{cv}$, classify observation t as belonging to an upward movement.

If $Z_t < Z_{cv}$, classify observation t as belonging to a downward movement.

Z_{cv} is defined as the critical value of Z_t and is calculated as follows:

$Z_{cv} = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 = 0.042$; Where:

x_i = the average of X_i group (uptrend or downtrend) means, and b_i = the estimated discriminant coefficients.

Evaluation and Comparison of Forecasting Accuracy of the Models

The primary means of evaluating a forecasting model should be based on how well it predicts. However, consistency of estimated signs with theoretical expectations and, in the case of regression, significance of the coefficients are also important. The t statistics indicate that all coefficients in the regression results are significantly different from zero with the exception of slaughter cattle price, which also exhibits an incorrect sign. The sign of B_1 is difficult to discern a priori. However, the remainder of the coefficient signs appear to be correct.[2/] The signs associated with the discriminant coefficients also coincide with expectations. The sign on B_2 suggests that if the price of yearlings is increasing (decreasing) it will continue to increase (decrease) to March, at least relative to October feeder calf prices.

Forecasting ability of the above models is evaluated according to how well price movements were predicted for the period 1925-1969 (the estimation period) and validated over the period 1970-1978 (beyond the estimation period). The results for the estimation period are reported in Table 2. For the period 1925-1969, the discriminant model properly classified 16 of the 21 upward price movements and 20 of the 24 downward price movements, or 80 percent of the cases. When compared to a chance model (e.g., flip of a coin) where 50 percent might be properly classified, the discriminant model is superior. A naive no-change model would have properly classified approximately 70 percent of the cases. In terms of picking up the turning points, i.e., when the direction of price movement changes, the model correctly predicted 11 of the 18 directional changes.

Using the same criteria as presented above, the regression model correctly classified 73 percent of the price movements and properly predicted 10 of the 18 turning points. The regression model is better than the chance model, but only slightly better than the naive no-change model. Theil's U_2 coefficient (calculated as suggested by Leuthold p. 345) is equal to 0.505 again indicating that the model is better than the naive no-change extrapolation. The discriminant model is thus superior to the regression framework in forecasting the direction of price movement between fall feeder calves and spring yearlings for the period of estimation, but only slightly better in terms of predicting turning points.

When the actual direction of price movement is added to the regression model as a dummy variable, Theil's U_2 coefficient decreases to 0.363 and the R^2 increases

Table 2. Discriminant and Regression Results, 1925-1969.

Year	Discriminant[a/] Actual	Discriminant[a/] Predicted	Regression Actual	Regression Predicted	Year	Discriminant[a/] Actual	Discriminant[a/] Predicted	Regression Actual	Regression Predicted
1925	1	1	3.429	3.072	1948	0	1*	-2.746	-1.504
1926	1	1	3.075	2.310	1949	1	1	1.148	-1.852*
1927	1	1	3.231	3.422	1950	1	0*	4.494	-2.239*
1928	0	0	-0.253	0.192*	1951	0	0	-8.239	-7.698
1929	0	0	-1.384	-1.064	1952	0	0	-7.019	-4.250
1930	0	0	-1.420	.2045*	1953	1	1	3.658	1.490
1931	0	0	-1.053	-1.456	1954	1	1	0.497	1.535
1932	0	0	-2.103	-3.192	1955	0	1*	-4.127	0.749*
1933	0	0	-0.387	-1.070	1956	1	1	0.123	2.117
1934	1	1	7.382	5.399	1957	1	1	0.902	2.760
1935	0	0	-0.414	0.427*	1958	0	0	-6.594	-3.286
1936	1	1	3.590	4.194	1959	0	0	-6.277	-4.818
1937	0	1*	-1.047	4.003*	1960	0	0	-1.736	-2.435
1938	1	0*	1.635	-.7261*	1961	0	0	-3.538	-3.206
1939	0	0	-1.370	-1.108	1962	0	0	-6.060	-2.335
1940	0	0	-0.429	-1.411	1963	0	0	-4.213	-2.972
1941	0	0	-1.224	-1.430	1964	1	0*	0.194	-1.439*
1942	1	1	2.275	0.778	1965	1	1	3.185	0.378
1943	1	0*	0.849	-1.039*	1966	0	1*	-4.105	-1.610
1944	1	1	2.808	1.893	1967	0	0	-1.890	.0078*
1945	1	1	2.727	1.862	1968	0	0	-0.240	-2.182
1946	1	1	5.128	3.706	1969	1	0*	0.383	-2.624*
1947	1	1	6.786	6.077					

[a/] A 1 indicates an upward movement in the direction of prices of yearlings relative to calves; 0 is a downward movement.

* Denotes an incorrect classification of price movement.

to 0.80. The estimated regression equation follows:

$$Y = -4.485 - 0.186X_1 +1.664X_2 -0.056X_3 +1.846X_4 +0.133X_5 +3.940X_6$$

$$(-1.427)\ (-2.029)\ (2.618)\ (-0.546)\ (2.643)\ (1.366)\ (5.955)$$

Where: Y = March yearling price in year t + 1 minus October feeder calf price in year t; X_6 = the direction of movement in fall feeder calf prices to the next spring yearling prices (1 if upward and 0 if downward).

Using information about the direction of movement of price in the regression framework not only improves the directional forecasts (96 percent correctly classified), as expected, but also the magnitude predictions, at least relative to a no-change model, as measured by Theil's U_2 coefficient. Thus, it appears worthwhile to predict price movement and incorporate this variable into a forecasting model, either by using the discriminant technique as outlined above or by other means to improve price forecasts. Also, information about the direction of movement in price may in itself be useful information in decisionmaking.

Table 3 contains the validation results of the model for the years 1970-1978. The discriminant model misclassified two of the nine cases. The two cases misclassified are turning points. The regression model also missed two cases.

The usefulness of the directional variable is perhaps of greater importance. Based on the values of Theil's U_2 coefficient (Table 3), incorporating the direction of movement in a regression model improved the forecasts over the model which did not include a measure of direction. Incorrect forecasts of direction may make the forecast of magnitude worse, or at least no better, as compared to omitting this variable, indicating further efforts are needed to improve directional forecasts.

Concluding Remarks

Overall, it appears that the discriminant analysis approach and the prediction and use of the direction of price movement are fruitful areas for further research and would benefit from input from the profession. Further research

Table 3. Predictions Using Discriminant and Regression Equations and Using Information Concerning the Direction of Movement in Price, 1970-1978.

	Discriminant 1/		Regression 1/			
Year	Actual	Predicted	Actual	Predicted W/O Direction Variable	Predicted W/ Actual Direction Variable	Predicted W/ Predicted Direction Variable
1970	0	0	-4.41	-2.77	-3.84	-3.84
1971	0	0	-0.63	-3.96	-4.69	-4.69
1972	1	0*	0.98	-4.19*	-0.50*	-4.44*
1973	0	0	-15.39	-7.91	-6.58	-6.58
1974	0	0	-1.03	-0.99	-1.75	-1.75
1975	1	0*	6.44	0.75	2.82	-1.12*
1976	1	1	0.48	0.80	2.21	2.21
1977	1	1	9.06	1.36	2.49	2.49
1978	1	1	16.50	-1.13*	0.76	0.76
				$U_2 = 0.84$	$U_2 = 0.75$	$U_2 = 0.82$

1/ Results obtained by using an average of cattle and calf slaughter for the first nine months of each year and multiplying by twelve. The September consumer price index was used as a proxy for the annual index to deflate prices.

* Donates an incorrect classification of price movement.

and tests are necessary to prove the validity of the model; such research might better be conducted for a different commodity where market perturbations are not as evident as in the beef industry. In addition, research should be directed toward the use of a directional component to predict a price level, rather than a price difference as used in this paper.

Footnotes

1/ For more complete discussions of discriminant analysis and/or its application to economic problems, refer to Araji and Finley, Bauer and Jordan, Blood and Baker, Bromley, Cooley and Lohnes, Duncan and Leistritz, Fisher, Morrison, Press, and Reinsel.

2/ The expected sign of the coefficient associated with the price of corn in a factor demand relationship is negative. However, in the case presented here, e.g., the difference between yearling and feeder calf prices, the relationship should be positive. Feedlot operators or feeders, in cases of high grain prices, pay premiums for heavier animals relative to lighter animals.

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