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MAR 15 1994

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**JOURNAL**  
*of*  
**STUDENT  
PAPERS**  
**1993**

WAITE MEMORIAL BOOK COLLECTION  
DEPT. OF AG. AND APPLIED ECONOMICS  
1994 BUFO RD AVE. - 232 COB  
UNIVERSITY OF MINNESOTA  
ST. PAUL, MN 55108 U.S.A.



## FEEDER CATTLE FORECASTING MODELS: AN ECONOMETRIC STUDY OF DEVELOPMENT AND PERFORMANCE

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### ABSTRACT

The purpose of this paper is to identify whether a complex forecasting model which takes into consideration expected sale price, expected cost of gain, and seasonality will perform better at forecasting quarterly feeder cattle prices than a simpler model based only on the futures price for feeder cattle. Restated, the objective is to discover if it is worth the time and effort to develop a complex model or whether futures prices serve as an adequate price forecast. Using data from the Agricultural Marketing Service of the USDA, the Chicago Board of Trade, and the Chicago Mercantile Exchange, econometric feeder cattle forecasting models were developed and used for forecasting. Out-of-sample forecasting performance of the models was evaluated. Both models performed similarly in their ability to predict the directional movement of the price of feeder cattle. Although both models exhibited good forecasting ability, econometric calculations demonstrated that the complex model had more accurate forecasting ability than the futures model.

### INTRODUCTION

Anticipation of future events has been an activity practiced by most people at one point in time or another. However, for some individuals it is a way of life. The livelihood of professional forecasters depends on their ability to anticipate future prices of commodities. If a forecast ends up substantially different from the actual price, customers lose faith in the forecaster's ability to perform. Market participants may lose substantial sums of money in lost profits or increased costs by using an inaccurate forecast to make decisions

to buy, sell, or store a commodity.

This scenario holds true for most markets, including the feeder cattle market. Making money in the cattle business depends on buying and selling at the right time for the right prices. In the cattle business, economic agents, including cow-calf producers, cattle feeders, and meat packers want to know the future price of cattle. Price is the single most important factor behind their sales and procurement decisions. This is where forecasting enters the scene.

Numerous professionals spend their life's work forecasting cattle prices. They spend years collecting data, studying the commodity, and trying to understand what determines cattle prices. Needless to say, many hours go into the development of models which will accurately forecast feeder cattle prices. Accomplishing this feat is no easy task given all of the variables, relationships, and natural occurrences which may affect the feeder cattle price.

The purpose of this paper is to identify whether a complex forecasting model which takes into consideration expected sale price, cost of gain, and

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### ACKNOWLEDGEMENTS

The author wishes to thank Dr. James Mintert for his assistance in the selection of the topic for this paper, assistance with possible variables to include in the models, assistance in locating data, and solving problems with the SAS program. Thanks is extended to Dr. Ted Schroeder for suggesting the addition of the feeder cattle futures model, for assistance in locating data, and for reviewing an earlier version of this paper which was prepared for his class AGEC 605, Price Analysis. The author also wishes to thank Dr. Andrew Barkley for devoting time to reviewing, helping edit, and improving an earlier version of this paper.

seasonality, among other variables, will provide better quarterly feeder cattle price forecasts than a simpler model based only on the futures price for feeder cattle. Restated, the objective is to discover whether it is worth the time, effort, money, and trouble it takes to develop a complex model to forecast feeder prices; or whether those interested in the prospective price would be better off simply depending on the futures price of feeder cattle as their forecast.

These objectives were accomplished by first developing a "complex" model containing several variables that may explain feeder cattle prices using quarterly data from 1975 through 1992 for Washington-Oregon 700-800 pound feeder steers. In specifying the original forecasting model, only data from 1975-1985 were used. Including the rest of the data would misrepresent the forecasting performance of the model, since the actual prices predicted would have been used to specify the model. The selected model was then run through a series of regressions in order to estimate the parameters for each year. These estimates were then placed back into the equation to make out-of-sample quarterly forecasts for 1986 through 1992. In predicting 1986 prices, data from 1975-1985 was used to estimate the parameters. The parameter estimates and the corresponding variables were placed in the model equation and forecasts were made. To predict 1987 prices, the model was recalculated using data from 1975-1986. This iterative procedure was continued for each of the successive years up to 1992.

The second step was to estimate a "simple" model which consisted of the lagged feeder cattle futures price as the only independent variable and employed the procedure outlined above to generate out-of-sample forecasts. The final step was to compare the out-of-sample forecasting performance of the two models. This was accomplished by computing the residuals

for both models. From the residuals the out-of-sample root mean squared forecast errors (RMSE) were computed and conclusions about which model more accurately predicted the feeder cattle prices were made.

## MODEL DEVELOPMENT

Dr. James Mintert, Extension Agricultural Economist in Livestock Marketing at Kansas State University, developed a model to forecast prices for Dodge City, Kansas, 700-800 pound feeder steers. In his paper entitled, "Forecasting Feeder Cattle Prices in 1990 and 1991," Mintert explained the price of feeder cattle to be a function of expected future cattle slaughter price and the expected cost of finishing the feeder animal to slaughter weight. Mintert's model employed quarterly average prices for Dodge City, Kansas, 700-800 pound steers in dollars per hundred weight as the dependent variable and deferred live cattle futures prices in dollars per hundred weight and deferred corn futures prices in dollars per bushel as the two independent variables.

In developing the complex model for this study, corn futures prices (\$/bu.), live cattle futures prices (\$/cwt), the interest rate on cattle loans (%), pasture and range conditions index for the specific location estimated and for the United States as a whole (%), and quantitative variables for seasonality were selected as possible determinants of feeder cattle prices. These variables were selected after consultation with Dr. Mintert. The actual equations estimated and explanations of the variables can be found in the Appendix of this paper.

Corn futures price was included as an independent variable because corn (or feed grain) is the major input in fattening cattle. The price of corn is the major component of the cost of gain. There is an expected inverse relationship between

feeder cattle prices and corn futures prices, so the sign of the coefficient for the corn futures variable is anticipated to be negative. Because this is a forecasting model, it is not possible to know the exact feed cost over the period of the forecast. Instead of developing a second model to forecast corn prices, the futures price of corn during the feeding period observed in the quarter prior to the forecast (the lagged corn futures price) was used.

The live cattle futures price was included because this is the price that a producer expects to receive when he sells his finished cattle. As live cattle prices increase, an individual will be willing to pay more for feeder cattle because the cattle feeder would expect a higher fed cattle price when selling the finished cattle. If the live future price decreases, the feeder cattle price will decline. These two prices have a direct relationship, resulting in an expected positive sign on the coefficient for this variable. As with the corn price, the lagged futures price was used instead of developing a separate model to forecast the live cattle price.

The interest rate on feeder cattle loans was included as an explanatory variable because it represents another cost to the producer. When a producer borrows money to purchase cattle, a low interest rate is preferred. If a high interest cost is sustained, then the cattle feeder will want to pay less for feeder cattle in order to preserve profits. Feeder prices and the loan interest rate are anticipated to have an inverse relationship. The sign on the coefficient should be negative.

Pasture and range conditions were included in the model to take into consideration weather conditions. If the weather is favorable and there is good grass and feed for the cattle, then a producer may spend more money on feeder cattle anticipating that they will perform well. Poor conditions may deter purchases or decrease prices paid as the producer tries to minimize

losses. In addition, poor range conditions often bring more cattle to market by those short of adequate pasture. The signs on the coefficients are expected to be positive. A qualitative (dummy) variable was included to account for missing pasture and range data.

Qualitative variables for the second, third, and fourth quarters were included to account for possible seasonality in the price of feeder cattle. The variable "dummy two" (D2) equals one in the second quarter and zero otherwise. The variables "dummy three" (D3) and "dummy four" (D4) are defined similarly for quarters three and four. The signs on the coefficients of the qualitative variables could be either positive or negative.

## DATA SUMMARY

Data for the models were obtained from various sources, and quarterly averages were computed for each series for the time period of 1975 through 1992. Weekly feeder cattle prices for Washington-Oregon 700-800 pound steers (\$/cwt) were acquired from the Livestock Marketing Information Center which is a joint venture of various state extension services and the United States Department of Agriculture (USDA). These prices were originally reported by the Agricultural Marketing Service of the USDA. Corn futures prices (\$/bu.) and live cattle futures prices (\$/cwt.) came from the Chicago Board of Trade and the Chicago Mercantile Exchange as reported in the Wichita Eagle newspaper. From the Crop Production published by USDA-National Agricultural Statistics Service, monthly pasture and range index conditions for the Washington-Oregon area and also for the United States as a whole were obtained. The Tenth District Federal Reserve in Kansas City, Missouri, was the source for the quarterly interest rates on feeder cattle loans. Feeder cattle futures prices were collected from the Chicago Mercantile

Exchange data base. In order to forecast quarterly prices, all data were converted to quarterly averages. All explanatory variables were lagged one quarter, so that the feeder cattle price forecast in quarter  $t$  was a function of the independent variables in quarter  $t-1$ . This was necessary since the objective was to forecast the price one quarter ahead of its occurrence.

## MODEL SELECTION

Replication of Dr. Mintert's work was the first step in developing the models for this study. For the dependent variable, the quarterly average price for Washington-Oregon (WA-OR) 700-800 pound feeder steers in dollars per hundred weight was selected. The selection of a feeder price from a different geographical location allowed a comparison of the same forecasting model performance in different locations. Once the final complex model was selected, it was used to make the forecasts for 1986-1992. All regression models were estimated using the SAS software program; while the quarterly forecasts were calculated in a spreadsheet.

Replication of Mintert's model (model 1) with Washington-Oregon replacing Dodge City, Kansas, as the dependent variable, demonstrated that the model had better results when used for Dodge City (refer to the Appendix for all model equations discussed, and Table 1 for regression results). T-statistic tests, which test whether the variables in the model are significantly different from zero, showed that both the live cattle futures price and the corn futures price were statistically significant in the Washington-Oregon model with t-values of 11.290 and -3.560 respectively. The coefficients of the variables also had the anticipated signs. However, the t-tests were stronger in the Dodge City model exhibiting t-values of 20.01 and -7.92, respectively. The  $R^2$  for the Washington-Oregon model

was 0.7886 which means that 78.86% of the variability in the Washington-Oregon 700-800 pound feeder steer price was explained by the model. The  $R^2$  for Mintert's Dodge City model was 8.14% higher than the regression reported here at 0.87, or 87%. The root means squared error (RMSE) for the Washington-Oregon model was \$5.8385/cwt. This means that the Washington-Oregon model has an error possibility of \$5.8385/cwt above or below the regression line of best fit. Mintert's model had a lower RMSE at \$5.10/cwt. Mintert's RMSE was therefore smaller than the regression in this study. It should be noted that Mintert's model used data from 1975-1990, rather than 1975-1985 as did the Washington-Oregon model presented here.

The second model contained the same variables as the first with the addition of qualitative variables for quarters two, three, and four (See Table 2). The qualitative variables were added to account for seasonality. All three qualitative variables (D2, D3, D4) had insignificant t-values of 0.347, -1.485, and -1.889, respectively. Model two did have a higher  $R^2$  value at 0.8255 and a smaller RMSE at \$5.53/cwt. The corn futures (L1QCORN) and cattle futures (L1QCAT) variables had significant t-tests (-3.810 and 12.007 respectively) and their coefficients had the expected signs. An F-test between models one and two showed the qualitative variables to be insignificant with an F-value of 1.905 and a critical F-value of 2.84 as reported in Table 2.

The third regression model contained the same variables as the second model, together with the L1QCATLN, the variable for the lagged interest rate on cattle loans. Because the F-test on seasonality was nearly insignificant, and an intuition that seasonality does affect feeder cattle prices, the qualitative variables were retained in the model. The L1QCORN AND L1QCAT variables remained significant with t-tests of -3.101 and 9.869 respectively. The three

qualitative variables again showed insignificant t-tests. The L1QCATLN variable was also insignificant with a t-value of -0.888. The  $R^2$  for model three increased only slightly to 0.8296, meaning that model three did not explain much more of the variability than did model two. The RMSE for model three was \$5.5512/cwt and the SSE was \$1016.9195/cwt<sup>2</sup>. The smaller SSE of model three indicated that this model had smaller residual values than model two. Signs on the parameter estimates were as expected.

In the fourth model estimated, the three qualitative variables were replaced with a Washington-Oregon range condition variable, QWARG. A qualitative variable, DWARG, was also used to account for missing values in the second quarters of all years in the lagged Washington-Oregon range condition variable (L1QWARG). The pasture and range conditions were not reported for December through April which made a first quarter average impossible to calculate. When lagged, this caused the second quarter to have a missing value. To remedy this problem, the second quarter missing values were replaced in the L1QWARG data with the same value as what the first quarter for that same year had. This was done for all years. Thus, the first and second quarter have the same values. In the second quarter, the qualitative variable DWARG is equal to whatever the second quarter value of the L1QWARG variable is. In quarters one, three, and four, DWARG equals zero.

Regression results for model four had less explanatory power than those of the previous two models (Table 2). The L1QCORN and L1QCAT variables still proved to be significant, and the L1QCATLN variable remained insignificant. L1QWARG and DWARG also showed little significance with t-tests of 1.182 and 1.783 respectively. They appeared to act mainly as replacements for the three seasonality dummy variables. The  $R^2$  of 0.8169 or

81.69% for model four was 1.27% below model three's value of 82.96% meaning less variability was being explained by model four. The RMSE increased to \$5.6686/cwt., and the SSE increased to \$1092.5027/cwt<sup>2</sup>, indicating larger errors in predictions by the model. The signs on the coefficients were as expected.

The fifth and final complex model contained only three independent variables, L1QCORN, L1QCAT, and L1QCATLN. With estimated t-values of -2.977 and 9.101, both futures variables again were statistically significant, but less so than in models one through four. The L1QCATLN variable was less significant than in models three and four having a t-test of only -0.634. The  $R^2$  for model five dropped to 0.7909, indicating that the model is only explaining 79.09% of the variability in feeder prices. Once again, the RMSE increased, this time to \$5.8863/cwt, the highest error of all five models. Parameter estimates continued to exhibit the anticipated signs.

Various other combinations of these and other variables were tested through regression models in the SAS program. However, their results were less significant and will not be discussed or formally reported in this paper. The five models presented here were selected after the statistical tests were performed.

From the five models presented here, model two,  $P_{QWOST78}^T = a_0 + b_1L1QCORN + b_2L1QCAT + b_3D2 + b_4D3 + b_5D4$ , had the best statistical results of the five models and was selected to use for the complex forecasting model. The t-tests for variables L1QCORN and L1QCAT exhibited the highest level of significance in model two. Model two also had the highest  $R^2$  and the lowest RMSE signaling, that it is explaining more variability in the feeder price than any other model, and also that it has the lowest error factor. Although the F-test between models two and one found the qualitative variables to be insignificant, they were retained in the model based on an intuition



that seasonality does have some bearing on the price of feeder steers. A look at the data showed that the price was usually highest in the spring and lowest in the winter.

## MODEL ESTIMATIONS AND RESULTS

Seven regressions were then run on model two in order to estimate the parameters of the regression equation. Seven regressions were needed because there are seven years in the time frame of 1986-1992, which are the years for which the price of Washington-Oregon feeder steers was to be forecast. Again, coefficients to forecast 1986 prices were obtained by estimating the model using 1975-1985 data. The 1987 coefficients were obtained using data from 1975-1986. Parameter estimates in subsequent years were obtained by following the same procedure. The coefficients, as well as the corresponding data for the variables, were then entered in the equation for model two. Using the data for the variables and their respective coefficients, quarterly forecasts were calculated for the seven years of 1986 through 1992.

The next procedure was to run a regression of the simple model (model 6) which used lagged feeder cattle futures prices (LAGFDRFT) as the only independent variable to forecast the quarterly prices for Washington-Oregon 700-800 pound feeder steers. The regression showed LAGFDRFT to be highly significant with a t-value of 11.925. The  $R^2$  for the LAGFDRFT model was 0.7899 meaning that the one independent variable explained nearly 79% of the variability in the price of feeder cattle. This was only 3.56% below the  $R^2$  of 82.55% of the complex model (model two). The RMSE for the LAGFDRFT model was \$5.7437/cwt indicating that the model had an error possibility of \$5.74367/cwt above or below the regression line. This was \$0.20987/cwt larger than the RMSE of

model two. The SSE of the LAGFDRFT model of \$1253.6125/cwt<sup>2</sup> was higher than that of 1041.1948 of model two.

Comparison of the two forecasting models' regression results (Table 2) indicated that the complex model did a better job of explaining the variability in Washington-Oregon 700-800 pound feeder cattle prices. However, it should be taken into consideration that model two contains four more variables than does the LAGFDRFT model. The number of added variables and not the variables themselves could possibly account for any statistical differences in the two models. Increasing the number of variables in a model will raise the  $R^2$  value and will also decrease the SSE value. Taking these facts into consideration, the models could be very close to providing the same information.

Following the same procedures used on model two, the LAGFDRFT model was run through seven regressions in order to acquire parameter estimates for 1986 through 1992. The parameter estimates were placed in the equation  $P_t^{QWOST78} = a_0 + b_1 \text{LAGFDRFT}_t$  along with the variable LAGFDRFT.

## FORECAST PERFORMANCE

Residuals for both models were calculated by subtracting the actual price for Washington-Oregon 700-800 pound feeder steers from the predicted price. The residuals were then squared and summed to calculate the SSE for both of the models. The average SSE was calculated by dividing the SSE by twenty-eight, the number of observations. The bias for each model was derived by using the formula  $E(\text{Forecast Price} - \text{Actual Price})/N$ . The root mean square estimate for the forecast (RMSE) was also computed. The RMSE for model 2 was subtracted from the RMSE of the LAGFDRFT model to get the difference between the models.



The statistical calculations demonstrated that the complex model did a slightly better job at forecasting the out-of-sample prices for Washington-Oregon 700-800 feeder steers. The SSE for the LAGFDRFT out-of-sample predictions was \$992.605/cwt<sup>2</sup>, while that of the complex model was \$234.275/cwt<sup>2</sup> smaller at \$758.33/cwt<sup>2</sup>. The LAGFDRFT model bias of \$3.74/cwt was \$2.59/cwt higher than the \$1.15/cwt bias of the complex model. This means that, on average, the LAGFDRFT model prediction was \$3.74/cwt higher than the actual price while that of the complex model was \$1.15/cwt higher. From looking at the bias, it is apparent that the complex model's forecasts are closer to the actual price than were those from the LAGFDRFT model. The final statistical comparison was of the root mean squared estimate (RMSE) for the forecasts of each model. Again, as was expected from studying the previous statistics, the LAGFDRFT model had the higher out-of-sample forecast RMSE of \$5.95/cwt. The RMSE for the complex model was \$5.20/cwt, a difference of \$0.75/cwt. The implications of this RMSE comparison are that the complex model did a better job than the LAGFDRFT model at forecasting the feeder steer price. The complex model exhibited more significant statistics in all areas, indicating that the model does forecast more accurately than the LAGFDRFT model.

When given the choice between the two forecasting models, those interested in predicting feeder cattle prices more accurately would select the complex model over the LAGFDRFT simple model. Not doing so would cause the forecaster to have greater forecast errors. If the forecaster merely wants to predict the general directional movement of the price, then either model would work effectively. However, when accurately forecasting the price is a job and not merely a hobby, the complex model is superior to a simpler one based only on the futures price. Cattle

producers, feedyards, and packing plants look to these forecasters for assistance in order to make business and management decisions. They depend on the forecaster to use the best model available.

## CONCLUSIONS

The purpose of this study was to determine whether a complex forecasting model which takes into account several variables related to the price of feeder cattle would perform better at forecasting out-of-sample prices than a simpler model based only on the futures price of feeder cattle. From the analysis, regressions, and predictions, the complex model possessed more accurate forecasting ability than the simple model. The simple model did not perform poorly in the test; however, it was out-performed by the complex model.

From the results of this study, it can be concluded that it is worth the time, effort, money and trouble that it takes to develop a highly accurate forecasting model. Knowing what variables and factors determine the price and including them in the model increases the accuracy of the forecast. It appears that those in the forecasting business who work hard at developing complex models rather than relying solely on the futures price are able to forecast feeder cattle prices with greater accuracy than those who do not.

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## APPENDIX

Equations for Forecasting Models Estimated<sup>a</sup>

- (1.) Model 1.  $P_t^{QWOST78} = F(\text{CORNFUT}_{t-1}, \text{CATFUT}_{t-1})$
- (2.) <sup>b</sup>Model 2.  $P_t^{QWOST78} = F(\text{CORNFUT}_{t-1}, \text{CATFUT}_{t-1}, D2, D3, D4)$
- (3.) Model 3.  $P_t^{QWOST78} = F(\text{CORNFUT}_{t-1}, \text{CATFUT}_{t-1}, \text{CATLN}_{t-1}, D2, D3, D4)$
- (4.) Model 4.  $P_t^{QWOST78} = F(\text{CORNFUT}_{t-1}, \text{QWARG}_{t-1}, \text{DWARG})$
- (5.) Model 5.  $P_t^{QWOST78} = F(\text{CORNFUT}_{t-1}, \text{CATFUT}_{t-1}, \text{CATLN}_{t-1})$
- (6.) <sup>b</sup>Model 6.  $P_t^{QWOST78} = F(\text{FDRFUT}_{t-1})$

where  $P_t^{QWOST78}$  = Quarterly average price for Washington-Oregon 700-800 pound feeder steers in time  $t$ .

<sup>c</sup>CORNFUT<sub>t-1</sub> = L1QCORN; Lagged corn futures quarterly price.

and where  $Q_1$  = January average of May CBT corn futures prices.  
 $Q_2$  = April average of July CBT corn futures prices.  
 $Q_3$  = July average of December CBT corn futures prices.  
 $Q_4$  = October average of March CBT corn futures prices.

<sup>c</sup>CATFUT<sub>t-1</sub> = L1QCAT; Lagged live cattle futures quarterly price.

and where  $Q_1$  = January average of October CME live cattle futures.  
 $Q_2$  = April average of December CME live cattle futures.  
 $Q_3$  = July average of April CME live cattle futures.  
 $Q_4$  = October average of June CME live cattle futures.

CATFUT<sub>t-1</sub> = L1QCATLN; Lagged quarterly interest rates from Tenth District Federal Reserve.

QWARG<sub>t-1</sub> = L1QWARG; Lagged quarterly average pasture and range conditions for Washington state.

DWARG = Dummy variable for the second quarter of the year.

D2, D3, D4 = Dummy variables for the second, third, and fourth quarters of the year respectively.

FDRFUT<sub>t-1</sub> = LAGFDRFT; Lagged quarterly average feeder futures prices.

<sup>a</sup>Equation development assistance from Dr. J. Mintert, Kansas State University.

<sup>b</sup>Model selected and used for forecasting.

<sup>c</sup>Explanations from "Forecasting Feeder Cattle Prices in 1990 and 1991" by Dr. J. Mintert, KSU.

**TABLE 1. REGRESSION RESULTS FOR 700-800 POUND STEER  
ONE QUARTER AHEAD PRICE FORECASTING MODELS**

Variable	Washington-Oregon 1975-85	Dodge City, Kansas 1975-90
Intercept	14.449 (2.163)	13.49 (2.92)
L1QCORN	-9.3397 (-3.560)	-10.79 (-7.92)
L1QCAT	1.2065 (11.290)	1.33 (20.01)
R2	0.7886	0.87
RMSE	5.8385	5.10

\*T-ratios are reported in parentheses beneath the respective parameter estimates.

**TABLE 2. REGRESSION RESULTS FOR WASHINGTON-OREGON  
700-800 POUND FEEDER STEER ONE QUARTER AHEAD  
PRICE FORECASTING MODELS, 1975-85**

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	14.449 (2.163)	15.53397 (2.375)	13.6893 (1.989)	4.4315 (.0479)	13.1777 (1.875)	6.4579 (1.440)
L1QCORN	-9.3397 (-3.560)	-9.5292 (-3.810)	-8.5287 (-3.101)	-9.8882 (-3.246)	-8.6021 (-2.977)	---
L1QCAT	1.2065 (11.290)	1.2291 (12.007)	1.3034 (9.869)	1.2861 (9.534)	1.2618 (9.101)	---
D2	--- (0.347)	0.86035 (0.450)	1.1252	---	---	---
D3	---	-3.6795 (-1.485)	-3.7309 (-1.500)	---	---	---
D4	---	-4.6882 (-1.889)	-4.6010 (-1.847)	---	---	---
L1QCATLN	---	---	-0.4327 (-0.888)	-0.3715 (-0.745)	-0.3239 (-0.634)	---
L1QWARG	---	---	---	0.1284 (1.182)	---	---
DWARG	---	---	---	0.0448 (1.783)	---	---
LAGFDRFT	---	---	---	---	---	0.8269 (11.925)
R2	0.7886	0.8255	0.8296	0.8169	0.7909	0.7899
RMSE	5.8385	5.5338	5.5512	5.6686	5.8863	5.7437
SSE	1261.2518	1041.1948	1016.9195	1092.5027	1247.3283	1253.6125

\*T-ratios are reported in parentheses beneath the respective parameter estimates.

\*Number of observations, n, for all models = 40.

\*F-test between Model 1 and Model 2 = 1.905