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# Improving Monthly Fed Cattle Price Forecasts with Information on Market-Ready Inventory

Kendall L. McDaniel and Stephen R. Koontz*

Market-ready inventories are cattle which have reached an adequate degree of feeding finish but which have not been sold. The level of market-ready inventories appear to have an important impact on fed cattle prices, are discussed in industry and outlook publications, but have not been used in fed cattle price models. This work finds that incorporating measures of market-ready inventories into autoregressive models of monthly fed cattle prices will improve explanatory power but not the forecast performance of these models. Public data are insufficient for forecasting over this time horizon.

## Introduction

Large periodic price declines have reduced the profitability of cattle feeding enterprises in recent years. The events during the summer 1994 provide an example of the problems predicting these changes. Early in 1994, outlook publications forecasted large numbers of cattle on feed for the last half of the year (USDA Livestock, Dairy, and Poultry: Situation and Outlook; Western Livestock Round Up; USDA Agricultural Outlook). The initial price decreases that occurred were unexpectedly large. Producers faced the choice to sell at a loss or hold cattle in the feedlot with the expectation of a moderate recovery later. Many producers held cattle and the resulting overfinished animals worsened the original situation. Outlook publications at this time did not recognize the large numbers of heavy market-ready cattle until late in the summer. Public information on market-ready inventory could have helped producers make more informed decisions and avoid the prolonged price decrease.

Market-ready inventories are cattle which have reached a minimum degree of finish but which have not been sold. Market-ready inventories are discussed in the industry and outlook publications. However, this idea has been ignored in price forecasting research. Cattle have traditionally been treated as a nonstorable commodity (Tomek and Gray; Leuthold). While it is likely that the time series techniques used in the most recent forecasting models (e.g., Zapata and Garcia; Garcia et al.; Bessler and Brandt; Harris and Leuthold) capture the dynamics of market-ready inventories, the research reported here examines the concept directly. The concept shows promise for improving fed cattle price forecasts. Information on inventory has been used to improve short-run fed cattle supply forecasts (Trapp) and market-ready inventory has been found to be more correlated with fed cattle prices than slaughter levels (Bacon et al.). However, these two works use private data. The research reported here examines the usefulness of market-ready inventory measures constructed from publicly reported data.

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The general objective of the research is to determine if public information on market-ready inventories can be used to explain and forecast monthly fed cattle prices.

## Fed Cattle Supply, Demand, and Dynamics

A variety of specifications have been used to model fed cattle supply, demand, equilibrium, and price dynamics. A reduced-form time series approach is used here. The approach is simple, incorporates the necessary hypotheses, and should result in effective forecasts. Further, a reduced form times series specification can be derived from a structural econometric model when the most important component variables have time series properties (Zellner and Palm).

Fed cattle supplies are influenced by profit-seeking feedlots depending on expected fed cattle prices and relative input prices. However, these supplies are largely determined by decisions made prior to the feeding enterprise. The cow herd size, heifer replacement decisions, and feedlot capacity largely determine the number of animals placed into feedlots and therefore fed cattle supply. In the long-run, expected fed cattle prices and relative input prices influence cattle feeding profitability and fed cattle supply. However, in the short-run, many input prices vary little over the feeding period or the input quantity is committed once the animal is placed on feed, or the input prices and quantities vary primarily with the season of the year. Feeder cattle placements and feed costs have strong seasonal components and influence short-run fed cattle supply. Furthermore, price expectations are also likely formed from past prices. Because of this structure, fed cattle supplies and prices have strong time series properties.

Demand for fed cattle begins with the consumer and is derived through retail, wholesale, and processing functions. Like other inputs for cattle feeding, in the short run, other inputs for cattle and beef processing are relatively fixed and have little influence on short-run derived demand. Further, consumer preferences for beef exhibit trends and vary seasonally, and are influenced by substitute meat prices which also exhibit trends and vary seasonally. Therefore, the effects of demand on fed cattle prices will have strong time series properties.

Equilibrium fed cattle price is determined by the balance of supply and demand. In the long-run, supply and demand determines fed cattle prices, and fed cattle are a continuously produced nonstorable commodity (Tomek and Gray; Leuthold). Reduced-form time series models have been used to represent fed cattle supply and demand. However, in the short-run, cattle can be held as market-ready inventory (Trapp; Bacon et al.). Current market-ready inventory will influence the relative bargaining power of cattle feeding enterprises versus meatpacking enterprises. Further, current market-ready inventories are determined by previous inventories, the number of new animals with adequate feeding finish, and current marketings. Thus, reduced-form time series models which include measures of market-ready inventories may be used to improve models of monthly fed cattle prices.

Two general models are specified. The first is a time series model where prices are modelled as a function of past prices and errors. The model is

$$P_t = \mu + \sum_{i=1}^{p} \phi_i P_{t-i} + \sum_{j=1}^{q} \theta_j \epsilon_{t-j} + \epsilon_t. \tag{1}$$

This is the baseline model. The parameters $\mu$, $\phi_i$, and $\theta_j$ are estimated. The second model is a transfer function which incorporates measures of market-ready inventories. The model is

$$P_t = \mu + \sum_{i=1}^{p} \phi_i P_{t-i} + \sum_{j=1}^{q} \theta_j \epsilon_{t-i} + \sum_{n=0}^{k} \delta_n MRI_{t-n} + \epsilon_t. \tag{2}$$

The parameters $\mu$, $\phi_i$, $\theta_j$, and $\delta_n$ are estimated. With different lags of the market-ready inventory variable, the hypothesis that market-ready inventories explain fed cattle prices ($n = 0$) and the hypothesis that market-ready inventories improve fed cattle price forecasts ($n > 0$) can both be tested. Three publicly available measures of market-ready inventories are used.

## Measuring Market-Ready Inventories

Cattle are on feed four-to-eight months depending on placement weight and growth rate. Higher feeder cattle placements result in higher marketings. Also, average placement weights and average growth rates vary across different seasons. Thus, past feeder cattle placements and season of the year are used to model fed cattle marketings. The model is

$$MKT_t = \beta_0 + \sum_{h=4}^{8} \beta_h PLC_{t-h} + \sum_{m=1}^{11} \alpha_m S_m + \nu_t. \tag{3}$$

where $PLC_{t-h}$ denote placements $h$ months prior to marketings $MKT_t$ in month $t$, and $S_m$ denotes the dummy variable for month $m$. If placements increase or decease, marketings will increase or decrease. However, feedlots can hold cattle as market-ready inventories. If predicted marketings do not equal actual marketings, market-ready inventories may be changing. A negative error term implies feedlots are holding cattle and a positive error indicates feedlots are marketing in excess of cumulative placements or are drawing down market-ready inventory. The direct measure of market-ready inventory is the negative of the residual

$$DMRI_t = \hat{MKT}_t - MKT_t = -(\hat{\nu}_t). \tag{4}$$

$DMRI_t$ should have a negative effect on future fed cattle prices. If current market-ready inventories increase, future fed cattle prices should decrease. However, $DMRI_t$ should have a positive effect on current fed cattle prices. If feedlots hold animals, marketings should decrease and prices increase this month. Figure 1 shows the relationship between $DMRI_t$ and fed cattle price changes. In January, February, and March 1994, market-ready inventories increased. Feedlots were holding cattle. Market-ready inventories were reduced in May, June, and July.

Indirect measures of market-ready inventories can be constructed through price discounts reported on different grades of beef. The first measure is the discount between yield grade 3 and yield grade 4 carcasses. The measure is

$$Y3Y4_t = Y3_t - Y4_t \tag{5}$$

where $Y3_t$ and $Y4_t$ are the average price of yield grade 3 and 4 carcasses. The Y3Y4 spread is the discount on meat from overfinished animals. Yield grade 4 animals are overfinished. Yield grade 3 is the industry standard. If the Y3Y4 spread is wide, there are many yield grade 4 animals relative to yield grade 3 animals. This usually indicates increasing market-ready inventories. The current Y3Y4 spread should be negatively related to future fed cattle prices. The Y3Y4 spread is also shown in Figure 1. In March and April 1994, the Y3Y4 spread was wide indicating large market-ready inventories.

The second measure is the choice and select discount. The measure is

$$CS_t = CH_t - SE_t \tag{6}$$

where $CH_t$ and $SE_t$ are the average price of Choice and Select grade carcasses. The CS spread is the discount for underfinished animals. Select animals have less fat then Choice and Choice are the industry standard. If the CS spread is wide, there are many Select animals relative to the number of Choice animals. This usually occurs with decreasing market-ready inventories. The current CS spread should be positively related to future fed cattle prices. The CS spread is also shown in Figure 1.

## Data and Hypotheses Tests

Monthly average prices of 11-13 hundredweight steers from direct trade in Western Kansas were used in the models. The Y3Y4 and CS spreads were calculated from average monthly prices for steer carcasses in Omaha-Central U.S. markets. The price data was reported by the USDA AMS and obtained from the Livestock Marketing Information Center. Marketings and placements data were reported in the monthly USDA seven-state *Cattle On Feed* report. The models were estimated using monthly data from January 1980 through December 1990. Out-of-sample forecasts were evaluated with data from January 1991 through December 1994.

Contemporaneous measures of market-ready inventory were used to test the hypothesis that the information can be used to explain fed cattle prices. Pairwise orthodox nonnested tests were used (Green). The tests involve nesting two measures into the baseline model and conducting F-tests. For example, Y3Y4 and CS were nested into the model. The null hypothesis is that Y3Y4 does not explain fed cattle prices. If the F-test fails to reject the null hypothesis, Y3Y4 does not provide unique information. If the F-test on CS also fails to reject the null hypothesis, the conclusion is that either Y3Y4 or CS or both contain no unique information for explaining price. If both tests reject the null, then both variables provide unique information. Pairwise tests were conducted for combinations of all three variables to determine which provide unique information for explaining prices.

Lagged measures of changes in market-ready inventory were used to estimate price forecasting models. The contemporaneous measures do not provide information timely enough for forecasting, past measures must be used. Forecasts from the models containing inventory measures are compared to baseline model forecasts. We test for a reduction in the forecast mean square error (Ashley et al.) and conduct turning point analysis (Leuthold).

## Fed Cattle Marketings Model

Table 1 reports the results of the fed cattle marketings model. The model was estimated using ordinary least squares. A polynomial distributed lag with endpoint restrictions was used to reduce collinearity. The degree of polynomial and lag length was selected based on Akaike's Information Criterion. The model explains 64.4% of fed cattle marketings. A strong seasonal pattern in marketings is found. Marketings are highest in the late summer and fall months and lowest in the late winter and spring months. Autocorrelation was found, but was not corrected. Market-ready inventories depend on past inventories and autocorrelation was expected.[1]

## Explaining Fed Cattle Prices

Table 2 reports parameter estimates, standard errors, and summary statistics for the models used to explain fed cattle prices. The Chi-square statistic is a test for autoregressive conditional heteroskedasticity. Homoskedasticity is not rejected. The baseline model was fit first. A Box-Jenkins approach was used after testing for stationarity. Prices were first differenced. An augmented Dickey-Fuller test indicated differencing was necessary. Autocorrelations and partial autocorrelations were examined to determine the structure of the time series process. A pure autoregressive model using price changes lagged one, two, and eleven months was determined to be best. Nearby prices capture current market conditions while the eleven month lag captures seasonality. P-values for Q-statistic in Table 2 show the residuals are white noise. The model R-square indicates that 30.3% of the month-to-month change in price is explained by the AR process. The squared correlation coefficient between actual and predicted price levels is 95.1%.

Models 2, 3, and 4 reported in Table 2 use measures of market-ready inventories in month *t* to explain price changes in month *t*. As expected, the coefficient on DMRI is positive. The signs on the Y3Y4 and CS spreads are also as expected. When feedlots to hold animals, the price in the current month increases. Likewise, when the Y3Y4 spread widens and the CS spread narrows, the price increases. The DMRI variable is significant at the 18.6% level in Model 2, Y3Y4 is significant at the 14.1% in Model 3, and CS is significant at the 0.3% level in Model 4. The three measures are used jointly in Model 5.

The R-square in Model 5 shows that 38.9% of the month-to-month change in fed cattle prices can be explained by AR process and the measures of market-ready inventories. The three measures explain 8.6% of the month-to-month change in price. However, the three measures only explain 0.4% of the variation in price levels. DMRI is significant at the 52.6% level,

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[1] Explicitly modelling the autocorrelation does not change any of the hypothesis test or forecast results.

Y3Y4 is significant at the 4.5% level, and CS is significant at the 0.2% level. T-tests indicate that DMRI is not important. However, this may be due to correlation between variables. Pairwise orthodox nonnested tests identify which variables contribute unique information.

Table 3 reports results of the pairwise orthodox nonnested tests. First, DMRI and Y3Y4 were nested in the AR model. The F-test on DMRI indicates that it is significant at the 13.5% level. The F-test on Y3Y4 indicates that it is also significant at the 13.5% level. Both of these tests fail to reject the null hypothesis. The conclusion is that Y3Y4 and DMRI contain the same information. Therefore, either Y3Y4 or DMRI, or both, should not be in the model. Second, DMRI was paired with CS. The F-tests indicate that CS provides unique information but that DMRI does not. Third, Y3Y4 and CS were paired. The tests indicate that both contain unique information. The results suggest that both the Y3Y4 and CS spreads should be used to explain monthly fed cattle price changes. Model 6 reports results from this specification.

Model 6 in Table 2 shows that 38.7% of the month-to-month change in fed cattle prices can be explained by past prices, and contemporaneous Y3Y4 and CS spreads. All the variables are significant at the 5% level. R-square improves 8.3% by including the spreads. The squared correlation coefficient predicted and actual price levels is 95.6%, a small improvement of 0.5%.

Market-ready inventories can explain fed cattle price. The results indicate that increasing market-ready inventories are correlated with price increases in the current month. When feedlots hold animals, marketings decline and prices increase. Further, pairwise orthodox tests indicate that the indirect measures of market-ready inventories, Y3Y4 and CS price spreads, perform better than the direct measure from the marketings model.

## Forecasting Fed Cattle Prices

Table 4 reports regressions using measures of market-ready inventories in month *t-1* to model price changes in month *t*. These models are used to forecast. The models are similar to those in Table 2. Regressions with additional lagged terms were also evaluated. The three measures were lagged one-to-four months cumulatively. However, price forecasts were not improved so the results are not reported. The first model in Table 4 is the baseline AR model.

Models 2, 3, and 4 each use one measure of inventory. Lagged DMRI is significant at the 31.1% in Model 2, lagged Y3Y4 spread is significant at the 33.6% level in Model 3, and lagged CS spread is significant at the 5.5% level in Model 4. The coefficient on the DMRI variable has the expected sign. Increased market-ready inventories in the previous month leads to lower prices in the current month. The signs on the Y3Y4 and CS spread are unexpected, they are the same signs as in the explanatory models. All three inventory measures are used in Model 5. The R-square for Model 5 is 35.7%. Lagged DMRI is significant at the 10.6%, and the sign is negative as expected. Y3Y4 is significant at the 14.4% level and CS is significant at the 1.3% level. However, the coefficients on the lagged spreads are opposite of expectations. Model 6 was estimated using the two price spreads. Y3Y4 is significant at the 17.5% and CS is significant at the 3.1% level. However, the signs are again unexpected. The R-square indicates that 3.7% of the variation in price is due to lagged spreads. The squared correlation coefficient is 95.3%, this is a marginal improvement over the baseline model.

Table 5 reports the out-of-sample forecast statistics for the models. The mean error of Model 1 is -\$0.29/cwt. The root mean squared error from Model 1 is \$1.91/cwt. One month ahead forecasts are unbiased, within \$2/cwt. of the actual price change two thirds of the time and within \$4/cwt. of the actual price change 95% of the time. Model 1 forecasts a correct market direction 34.0% of the time and forecasts the opposite move 12.8% of the time. The mean squared errors for all other models are larger than for the AR model. Models 2, 4, and 6 perform slightly better as compared by the percent of correct directional forecasts. However, the percent of worst case forecasts is also higher for these models. Thus, there is little improvement in forecasting according to this criterion. Models 3 and 5 perform worse than the AR model in all categories. Because all models have mean squared errors that are worse that the baseline, there is no need to report results of the mean squared error tests.

The results indicate that lagged measures of market-ready inventories using public data do not improve fed cattle price forecasts. The reason that forecasting is not improved may be due to three things. One, past prices and the dynamics of the time series model are capturing the information contained in the market-ready inventory measures. Two, the relationship between changes in market-ready inventories and price may be measurable only in the current month. Thus, the forecast horizon of one month is too long. Three, the data used to measure changes in market-ready inventories are inadequate. A one month time period may aggregate too many changes in market conditions to be useful for predicting next month's average price.

## Conclusions

Market-ready inventory is an important concept for evaluating fed cattle price outlook. It is discussed in reports and by industry members. It has been used to improve forecasts of short-run fed cattle supply and it has been found to be more strongly correlated with price than slaughter levels. Further, this work shows that measures of market-ready inventory can be used to explain changes in fed cattle prices. However, market-ready inventory does not improve monthly fed cattle price forecasts.

One conclusion is that the *Cattle On Feed* report should contain a weight breakdown of animals on feed. This would allow all producers to monitor feedlot inventories, reduce forecasting errors, and make more informed decisions. A second conclusion is that feedlots need to recognize the effect of market-ready inventories on prices and make better decisions so large unexpected price decreases can be avoided. Weekly data on market-ready inventories instead of monthly data may be needed to improve short-run price forecasts. Also, comparing these results to private data results would indicate whether or not private data can be used to monitor feedlot inventories.

Table 1. Parameter Estimates, Standard Errors, and Summary Statistics of the Fed Cattle Marketings Model using data from January 1980 through December 1990.

| Variable | Estimate | Variable | Estimate |
|---|---|---|---|
| Intercept | 705.421<br>(102.5) | April | -117.04<br>(43.09) |
| $Placements_{t-4}$ | 0.0877<br>(0.0238) | May | -8.7917<br>(44.56) |
| $Placements_{t-5}$ | 0.1261<br>(0.0234) | June | 103.28<br>(39.5) |
| $Placements_{t-6}$ | 0.1258<br>(0.0170) | July | 159.75<br>(31.97) |
| $Placements_{t-7}$ | 0.0975<br>(0.0225) | August | 219.28<br>(33.76) |
| $Placements_{t-8}$ | 0.0520<br>(0.0231) | September | 102.27<br>(35.12) |
| January | 182.64<br>(36.15) | October | 118.06<br>(32.88) |
| February | -85.113<br>(56.15) | November | -12.969<br>(31.34) |
| March | -86.852<br>(51.66) | F-Statistic<br>R-Square | 14.2276<br>64.41% |

Table 3. F-Statistics, P-Values, and Conclusions of the Orthodox Nonnested Tests.

| Variables | F-statistic | P-Value | Conclusion |
|---|---|---|---|
| $DMRI_t$ | 1.851 | 0.135 | DMRI or Y3Y4 should not be in model |
| $Y3Y4_t$ | 2.271 | 0.135 | |
| $DMRI_t$ | 0.451 | 0.504 | DMRI should not and CS should be in model |
| $CS_t$ | 7.895 | 0.006 | |
| $CS_t$ | 4.186 | 0.043 | CS and Y3Y4 should be in model |
| $Y3Y4_t$ | 11.443 | 0.001 | |

Table 2. Parameter Estimates, Standard Errors, and Summary Statistics of the Models Explaining Monthly Fed Cattle Price Changes from January 1980 through December 1990.

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| Intercept | 0.1146<br>(0.2080) | 0.1586<br>(0.2098) | -1.1327<br>(0.8667) | 1.2412<br>(0.4186) | -0.3305<br>(0.8646) | -0.3057<br>(0.8612) |
| $Price_{t-1}$ | 0.2805<br>(0.0864) | 0.2586<br>(0.0876) | 0.2780<br>(0.0859) | 0.2479<br>(0.0837) | 0.2328<br>(0.0839) | 0.2414<br>(0.0825) |
| $Price_{t-2}$ | -0.1964<br>(0.0856) | -0.1682<br>(0.0879) | -0.1766<br>(0.0862) | -0.1619<br>(0.0831) | -0.1208<br>(0.0853) | -0.1321<br>(0.0832) |
| $Price_{t-11}$ | 0.4154<br>(0.0718) | 0.411<br>(0.078) | 0.3995<br>(0.0785) | 0.3668<br>(0.0769) | 0.3413<br>(0.077) | 0.3407<br>(0.0768) |
| $DMRI_t$ | | 0.0045<br>(0.0034) | | | 0.0021<br>(0.0033) | |
| $Y3Y4_t$ | | | 0.11074<br>(0.0747) | | 0.1463<br>(0.0722) | 0.1474<br>(0.072) |
| $CS_t$ | | | | -0.2482<br>(0.081) | -0.2605<br>(0.0833) | -0.273<br>(0.0807) |
| F-statistic | 15.094 | 11.848 | 11.999 | 14.579 | 10.723 | 12.862 |
| Q-statistic | 1.52 | | | | | |
| Chi-square | 0.104 | 0.069 | 0.206 | 0.535 | 0.55 | 0.618 |
| R-Square | 30.33% | 31.51% | 31.79% | 36.15% | 38.91% | 38.67% |
| Price Level Correlation | 95.145% | 94.879% | 95.280% | 95.435% | 95.568% | 95.626% |

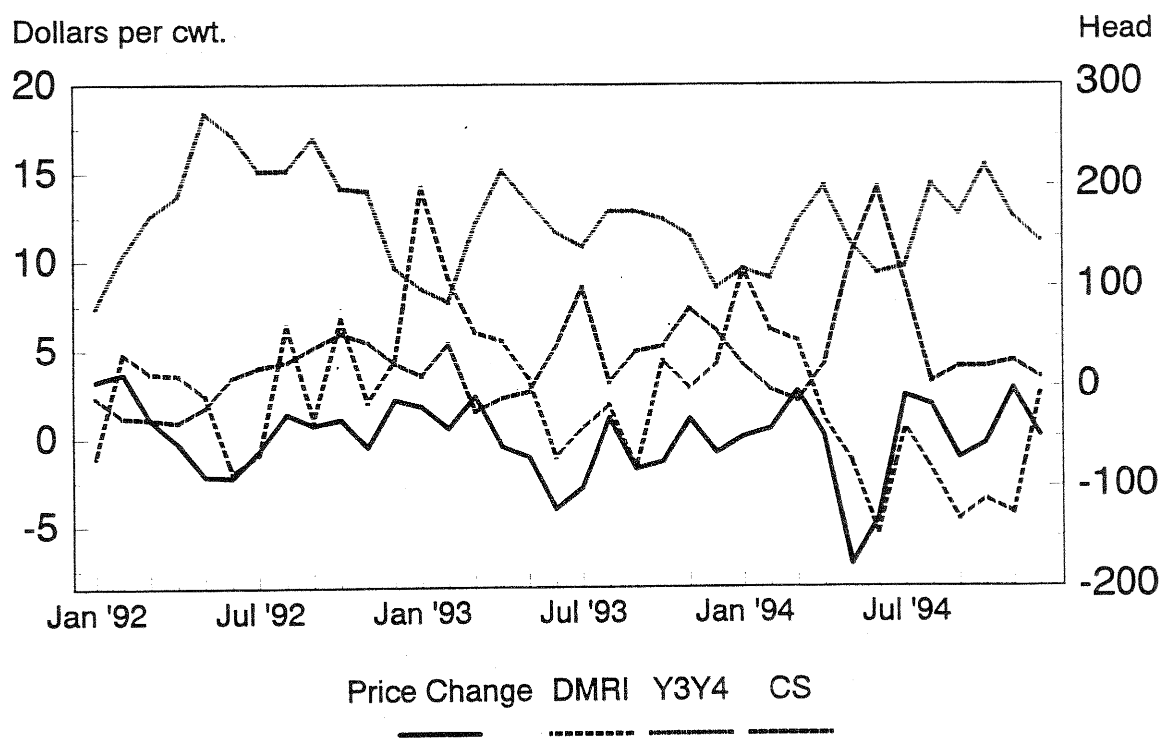
Table 4. Parameter Estimates, Standard Errors, and Summary Statistics of the Models Used to Forecast Monthly Fed Cattle Price Changes.

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| Intercept | 0.1146 | 0.0763 | -0.7067 | 0.8832 | -0.1635 | -0.1780 |
| | (0.208) | (0.2113) | (0.8749) | (0.4425) | (0.8856) | (0.8927) |
| $Price_{t-1}$ | 0.2805 | 0.2963 | 0.2638 | 0.2176 | 0.1968 | 0.1859 |
| | (0.0864) | (0.0877) | (0.0881) | (0.0910) | (0.0931) | (0.0936) |
| $Price_{t-2}$ | -0.1964 | -0.1910 | -0.1907 | -0.1985 | -0.1817 | -0.1907 |
| | (0.0856) | (0.0858) | (0.0859) | (0.0845) | (0.0838) | (0.0843) |
| $Price_{t-11}$ | 0.4154 | 0.4123 | 0.4109 | 0.4173 | 0.406 | 0.4111 |
| | (0.0718) | (0.0782) | (0.0783) | (0.0771) | (0.0764) | (0.0770) |
| $DMRI_{t-1}$ | | -0.0034 | | | -0.0055 | |
| | | (0.0034) | | | (0.0034) | |
| $Y3Y4_{t-1}$ | | | 0.0729 | | 0.1104 | 0.1031 |
| | | | (0.0755) | | (0.0749) | (0.0754) |
| $CS_{t-1}$ | | | | -0.1688 | -0.2254 | -0.1906 |
| | | | | (0.0861) | (0.089) | (0.0872) |
| F-statistic | 15.094 | 11.582 | 11.547 | 12.590 | 9.363 | 10.531 |
| Q-statistic | 1.52 | | | | | |
| Chi-square | 0.104 | 0.024 | 0.108 | 0.145 | 0.001 | 0.02 |
| R-Square | 30.33% | 31.02% | 30.96% | 32.84% | 35.74% | 34.05% |
| Price Level Correlation | 95.145% | 95.210% | 95.211% | 95.229% | 95.448% | 95.326% |

Table 5. Out-of-Sample Forecast Statistics.

| Variables | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| Mean Error | -0.2907 | -0.2631 | -0.3190 | -0.3202 | -0.3284 | -0.3640 |
| Mean Square Error | 3.6316 | 3.6692 | 3.8205 | 3.7898 | 4.4419 | 4.1866 |
| Root Mean Square Error | 1.9057 | 1.9155 | 1.9546 | 1.9467 | 2.1067 | 2.0461 |
| % Correct Direction | 34.04% | 36.17% | 31.11% | 36.17% | 31.91% | 36.17% |
| % Worst Case Direction | 12.77% | 14.89% | 13.33% | 14.89% | 14.89% | 19.15% |

Figure 1. Changes in the Fed Cattle Price, the Direct Measure of Market-Ready Inventory, the Yield Grade 3 versus Yield Grade 4 Carcass Discount, and the Choice versus Select Carcass Discount for January 1992 through December 1994.



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