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Forecasting Quality Grade and Certified Angus Beef Premiums

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Forecasting Quality Grade and Certified Angus Beef Premiums

We evaluate the mean squared error and mean absolute percentage error of alternative forecasts of quality grade and Certified Angus Beef (CAB) premiums, which may be of interest to cow-calf producers, feeders, and packers. A supply and demand model and a vector autoregressive model outperform a naïve model accounting for only seasonal effects for all premiums except the strongly seasonal Choice-Select spread. While there is no significant difference between the supply and demand model and the vector autoregressive model in terms of mean squared error, the supply and demand model outperforms the vector autoregressive model in terms of mean absolute percentage error in predicting the CAB-Choice premium.

Keywords: causality, efficient market hypothesis, forecasts, futures, information transmission

Introduction

Risk and uncertainty are prominent features of cattle feeding. Commercial feeders continually face the decision to either market a particular lot of cattle at current weights or continue feeding them for sale at a later date, and several studies endeavor to forecast cattle prices to help inform such decisions (Bullock & Logan, 1970; Foster, Havenner, & Walburger, 1995; Spreen & Arnade, 1984; Zapata & Garcia, 1990). More recent studies investigate how marketing behavior of cattle feeders has been influenced by the transition from average lot pricing—the dominant form up to the 1990s—to a value-based (i.e., carcass-merit or grid) approach in efforts to combat loss of market share to more consistent pork and poultry products (Fausti, Wang, Qasmi, & Diersen, 2014; Greer, Trapp, & Ward, 2000; Johnson & Ward, 2006; Schroeder & Graff, 2000). Yet, no study attempts to forecast the quality grade premiums/discounts associated with grid pricing or premiums for branded programs like Certified Angus Beef® (CAB).

The objective of this study is to develop and compare the accuracy of alternative forecasts of weekly average prime-choice, CAB-choice, and choice-select premiums five months out or about the duration that cattle are on feed. Such forecasts may be useful for commercial feeders and possibly cow/calf and backgrounding operations, as producers of higher quality cattle and those that desire feedlot and carcass data for herd management decisions are more interested in retained ownership and backgrounding (Franken, Parcell, Smith, & Poock, 2010; Mark, Schroeder, & Jones, 2000; Pope, Schroeder, Langemeier, & Herbel, 2011). Additionally, the retail and food service industries are becoming increasingly consolidated and sophisticated in procurement, working directly with packers in long-term formula and forward contracts (McCully, 2010). The forecasts described herein may be beneficial in facilitating exchange at this level as well.

The first forecast builds on a supply-demand oriented framework. The demand equation models grade premiums (i.e., the price of higher quality) as a function of pounds (lbs) of beef carcasses by quality grade (e.g., prime, choice, select), annual U.S. population and gross domestic product

(GDP), a logarithmic time trend, and monthly dummies to capture seasonality. Since cattle are fed in feedlots for about five or six months (Bullock and Logan, 1970; Foster, Havenner, and Walburger, 1995), the U.S. beef supply (lbs) grading prime, choice, select, and other is predicted by Kansas City corn prices, feeder cattle and live cattle futures prices, grade premiums/discounts, and monthly reported average weight of cattle placed on feed 150 days earlier, along with the trend and monthly dummies. These projections and USDA forecasts of U.S. population and real per capita GDP are entered into the demand equation to compute direct forecasts of quality grade and CAB-choice premiums. The out-of-sample performance of these direct forecasts, as measured by mean squared error (MSE) and mean absolute percentage error (MAPE), is compared to that of a naïve model of premiums as a function of only seasonality and autoregressive time series models that also include lagged premiums to respectively develop direct forecasts and iterated forecasts using predicted values in subsequent projections. Recent research investigates the relative performance of direct forecasts multiple periods out (i.e., horizon $h>1$) and iterated forecasts under various scenarios of structural shifts and statistical properties of the data with mixed results (Chevillon, 2006; Pesaran, Pick, & Timmermann, 2011).

The paper is organized as follows. The next section presents a brief review of the relevant literature, informing the choice of empirical procedures, which are discussed following a brief description of the data. Then the results are presented, followed by a discussion of their implications in the concluding section of the paper.

Relevant Research

Forecasts of cattle prices tend to focus on short-term horizons and can be classified under two general approaches—those reflecting the structure (supply and demand) of cattle markets and those utilizing time series methods employing lags of prices (Bullock & Logan, 1970; Foster et al., 1995; Spreen & Arnade, 1984; Zapata & Garcia, 1990). Traditionally, forecasts are evaluated using mean squared error (MSE) and more recently mean absolute percentage error (MAPE).

Bullock and Logan (1970) construct feed longer or sell criteria using one month ahead forecasts of average monthly prices for 900-1100 lb choice slaughter steers in El Centro, California as a function of lagged prices, predicted marketings of fed cattle, and quarterly dummy variables. Fed cattle marketings are predicted from the number of cattle on feed by weight group, quarterly dummy variables, and a time trend. The study demonstrates the usefulness of Bayesian analysis for combining information from price forecasts with decision makers' subjective evaluations.

Foster et al. (1995) develop short-run (one to six weeks) multivariate time-series forecasts of weekly live cattle prices in six markets (Texas Panhandle Direct, Illinois Direct, Iowa-S. Minnesota Direct, Omaha Terminal, St. Paul Terminal, Sioux City Terminal). Simulations indicate that the price predictions, coupled with the capability to postpone the sale of cattle, yield profitable arbitrage opportunities.

Spreen and Arnade (1984) evaluate the decision to overwinter feeder cattle and compare alternative forecasts of spring stocker cattle prices derived from naïve (no price change), trend only, autoregressive integrated moving average (ARIMA), and fundamental supply and demand oriented (ranch and corn costs and feedlot marketings) models. While the fundamental model posted the best out-of-sample MSE, the trend model performed better in terms of the proportion of correct decisions implied (sell or overwinter) and the associated profitability of the choice.

Zapata and Garcia (1990) evaluate the forecasting performance of various time series (ARIMA, vector autoregression or VAR and error correction) models of slaughter steer prices in the presence of nonstationarity. Their results emphasize testing for types of nonstationarity, as procedures that admit model specifications corresponding to the system's dynamic offer greater accuracy based on the root mean-squared error (RMSE), a MSE decomposition, and turning point analysis.

While some of the prior research forecasting cattle prices is dated, there is no reason to believe the fundamental structure of cattle feeding and sales decisions have changed. There have been both structural and technological changes over time, but the biological features of cattle production remain relatively stable. We next describe the data used for the analysis here.

Data

The analysis utilizes publicly available data reported by the US Department of Agriculture (USDA) and the CME Group spanning November 2, 1996 through January 11, 2016 (Table 1). The Livestock Marketing Information Center (LMIC) was the source of the data files constructed from these sources. Data on quality grade and CAB premiums, head of steers and heifers slaughtered, percentage of steers and heifers in each grade category, and average dressed weights for steers and heifers are available on a weekly basis. Each series on steers and heifers is multiplied to approximate the weekly supply of beef in lbs for each grade. The weekly data are aligned by date with daily spot corn prices and feeder and live cattle futures contract prices. Similarly, monthly average placement weights for cattle placed on feed and annual data on population and per capita gross domestic product are included in the weekly dataset for corresponding months and years, respectively.

Summary statistics are given in Table 2. For the purpose of the analysis, discounts for quality grades below choice are adjusted to positive values so that we can evaluate premiums for each incremental increase in quality grade, which will simplify the interpretation of regression results. Quality premiums vary considerably with *Choice-Select* exhibiting the greatest variation and *CAB-Choice* the least (standard deviations of 4.25 and 1.03, respectively). At $2.39/cwt, *CAB-Choice* is also the smallest premium on average, while *Standard-Select*, as the largest, is nearly five times as big. While placement and dressed weights also vary substantially, cattle are placed on feed at an average weight of about 705 lbs and harvested with dressed weights of about 792 lbs. *Steer & Heifer Slaughter* ranges from about 308,260 to 656,360 head per week. Multiplying this series by the percentage of cattle in each grade yields the number of head in each grade category, which is then multiplied by the average carcass dressed weight for all steers and heifers to approximate the pounds of each grade of beef on a weekly basis. Consistent with the variation in quality premiums, the quantity of choice and select beef varies markedly more than other grades. Much of the variation in the supply of choice and select beef is seasonal, which translates into strong seasonality in the *Choice-Select* premium relative to other grade premiums (Figure 1). According to Fausti et al. (2014), the choice-select price differential is the dominant premium/discount category explaining per-head revenue variability, and a change in the choice-select spread alters financial risk, the magnitude of which depends on cattle quality.

As expected, Dickey-Fuller tests are unable to reject the null hypothesis of nonstationarity for some of these data series, and hence differencing the data would be warranted if inferences about coefficient significance were the primary objective of the study. However, we proceed with analysis of the data in levels, since our primary focus is forecast accuracy.

Empirical Methods and Procedures

Futures market prices are typically considered the best benchmark against which to evaluate alternative forecasts. In the absence of futures markets for beef quality grade premiums, we consider a naïve seasonal model composed of only monthly dummy variables to account for seasonality (Figure 1) as a benchmark for comparison. Forecast models are calibrated using approximately 14 years of data from November 2, 1996 through December 31, 2010, saving the remaining observations for out-of-sample forecasting. Each forecast model is estimated using seeming unrelated regression across equations for each grade.

Following Bullock and Logan (1970), fed cattle prices may be modeled as a function of fed cattle marketings, and fed cattle marketings can be modeled as a function of appropriately lagged numbers of cattle placed on feed with dummy variables accounting for seasonality in both models. Adapting this general approach, we construct supply and demand models for various quality grades of cattle that are estimated using seemingly unrelated regressions. The inverse demand equation is specified as

$$P_{GT} = f(LN[Q_{GT}], POPULATION_T, GDP_T, LN[T], M_T), \quad (1)$$

where P_{GT} denotes the premium for quality grade G in time T, $LN[Q_{GT}]$ is the natural logarithm of lbs of beef marketed in each grade category, $POPULATION_T$ and GDP_T are the U.S. population and real per capita gross domestic product in the respective year, $LN[T]$ is the natural logarithm of T, M_T represents a vector of monthly dummy variables. $LN[Q_{GT}]$ variables for both grades corresponding to the premium or spread represented by P_{GT} are included in the respective demand equations. For instance, when modeling P_{PrimeT}, both $LN[Q_{PrimeT}]$ and $LN[Q_{ChoiceT}]$ are included in the inverse demand equation with negative and positive effects expected, respectively. The supply equation is specified as

$$LN[Q_{GT}] = f(P_{GT\text{-}t}, CORN_{T\text{-}t}, FEEDER_{T\text{-}t}, FAT_{T\text{-}t}, PLACE\_W_{T\text{-}t}, CARCASS\_W_{T\text{-}t}, LN[T], M_T), \quad (2)$$

Where $P_{GT\text{-}t}$ represents the premium for quality grade G at the beginning of the feeding period, $CORN_{T\text{-}t}$ is the corn price in Kansas City at the beginning the feeding period, $FEEDER_{T\text{-}t}$ and $FAT_{T\text{-}t}$ are the nearby feeder cattle and live cattle futures contracts at the beginning of the feeding period, and $PLACE\_W_{T\text{-}t}$ and $CARCASS\_W_{T\text{-}t}$ are average placement weights and dressed weights for steers and heifers at the beginning the feeding period. The lag t is initially assumed to be 22 weeks or about five months—the typical duration cattle are on feed. Alternative lags are considered for $P_{GT\text{-}t}$, and t=117 weeks (nearly 27 months) is determined to be appropriate, which corresponds to about nine months gestation plus a year and a half slaughter age and reflects cow-calf producers responding to grade premiums when making breeding decisions. Whereas shorter lags exhibit statistically negative effects in the supply equation, this lag returns more intuitive significantly positive effects for at least some quality grade pricing models. Once estimated, the supply model can be used to project relative supplies of cattle slaughtered at various grades five months out based on information known when these animals are placed on feed, and those estimates along with USDA projections for U.S. population and real per capita GDP are entered into the demand equation to predict quality grade premiums.

In addition to the variables described above, a dummy variable equal to one for year 2000 and thereafter (and equal to zero previously) is included in each supply and demand equation to account for the influence of the Atkins' diet and related trends toward consumption of leaner meats, and a corresponding dummy variable accounting for a change in CAB yield grade specifications put into effect on January 23, 2007 is included in associated supply and demand equations (Corah & McCully, 2009).[1] The latter dummy variable is equal to one for year 2007 and thereafter (and equal to zero previously).

Following Zapata and Garcia (1990), vector autoregressive (VAR) models are of considerable interest for forecasting the value of fed cattle. Applying our notation to the standard form, a VAR model of beef grade premiums including monthly dummies M_T may be given by

$$P_{GT} = f(P_{GT-t}, M_T) \text{ for } t=1\text{-}p, \qquad (3)$$

where P_{GT} is a vector of G endogenous variables (e.g., prime, CAB, choice, select, and standard premiums/discounts) at time T that are a function of their lagged values up to T-p and monthly dummies with error e_T. The optimal lag length of three lags is chosen based on minimizing Akaike information criterion (AIC).

Results

Naïve Seasonal Model

Regression results for the naïve seasonal model are presented in Table 3. Recall that discounts (negative values) are converted to premiums (positive values) for modeling purposes. R-square values are notably low for these simplistic models. While still low, the greatest percentage of premium variability explained by these models is nearly 16% of the *Choice-Select* spread, which exhibits the strongest seasonality of the premiums. Consistent with Figure 1, significantly negative coefficients for February and March reflect that cattle tend to grade better and middle-meat demand is typically lower in this period (McCully, 2010). The substitutability of select and choice beef is lower and demand for both grades becomes more inelastic in the spring and summer than in the fall and winter (Hughes, 2002). Significantly positive coefficients indicate greater premiums exist for choice beef during grilling season in May and June when demand for middle-meats is strong and cattle grading is near seasonal lows (McCully, 2010). Similar grilling season effects are observed for the CAB-Choice spread. The *Choice-Select* spread typically rallies again through the early fall as relative supply of upper grades remains low and holiday rib and tenderloin demand strengthen, as reflected by significantly positive coefficients for October through December dummy variables. Similar affects are observed in September and October for the *Prime-Choice* spread. Since similar seasonal affects are apparent in alternative regressions presented below, coefficients for monthly dummy variables are omitted from reported results in the interest of space.

Supply & Demand Model

Results for supply and demand regressions are presented in Tables 4 and 5, respectively. R-squares are notably better for these models than for the naïve seasonal model. Unfortunately, reliable data on the supply of beef qualifying for CAB is unavailable for the sample period, and hence, supply is estimated only for the four quality grades. Supply regressions model the natural logarithm of lbs in each grade category as a function of associated premiums observed 27 months earlier (117 weeks) when cow-calf producers made breeding decisions that resulted in the corresponding slaughter animals and several other variables lagged five months (22 weeks) when those slaughter animals were initially placed on feed. The lagged *Prime-Choice* premium has a statistically positive effect on the supply of prime beef 27 months later which may reflect some responsiveness by cow-calf producers to incentives inherent in that premium.[2] Similarly, the *CAB-Choice* premium has a statistically positive effect on the supply of choice beef, while the *Choice-Select* premium conversely has a statistically negative effect, and the *Select-Standard* premium has no significant influence on supplies of select or standard beef.

The lagged Kansas City corn price, when significant, has counterintuitive effects with higher corn prices leading to more prime beef and less select beef (Table 4). Perhaps corn price levels closer to the time of slaughter might have more intuitive effects, but such relationships would be uninformative for forecasting five months out. Feeder and live cattle futures contract prices generally have significantly negative effects on the supply of higher quality beef and positive effects on that of lower quality beef. It may be that cattle are generally slaughtered at lighter weights when prices are more profitable and fed to heavier weights in search of quality premiums when prices are not as good. When placement weights and carcass weights are heavier, supplies of beef generally tends to increase across grade categories 5 months later. The logarithmic trend variable and post-2000 and post-2007 dummies, described above, are also included and exhibit consistently significant effects. The post-2007 dummy variable, corresponding to the change in CAB specifications to allow yield grade four in addition to the prior standard of yield grade 3, is included only in the Choice supply equation and exhibits a statistically positive effect consistent with the push to qualify more cattle to meet demand for CAB. The post-2000 dummy variable has statistically positive effects in each supply equation, while the logarithmic trend variable indicates declining supply in each grade category for the sample period overall.

The inverse demand equations model premiums as a function of quantities of beef for associated grades, macroeconomic variables (population and per capita GDP), as well as the logarithmic trend and post-2000 and post-2007 dummies (Table 5). Intuitively, supplies of the higher and lower grade associated with particular premiums often have significantly negative and positive effects, respectively. For instance, a greater supply of choice beef tends to decrease the *Choice-Select* premium, while a greater supply of select beef tends to increase it. Results also indicate that increases in annual per capita GDP tend to increase premiums for high quality beef and decrease those for choice and lower quality beef, which tend to increase with population growth.

The logarithmic trend term indicates declining periods for CAB and higher quality beef and an increasing *Choice-Select* premium. The post-2000 dummy has negative effects for each premium which are statistically significant for *Prime-Choice* and *Choice-Select* premiums, which may reflect preferences for leaner meat influenced by the Atkins' diet and related nutritional regimes. The post-2007 dummy has a statistically positive effect on *Prime-Choice* and *CAB-Choice*, and a statistically negative effect on *Choice-Select* premiums, which may reflect changing availability and demand for CAB and choice beef.

Vector Autoregressive Model

Regressions results for VAR models are reported in Table 6. Though not reported in the interest of space, monthly dummy variables again are included in the model to account for seasonality. The optimal lag length of three weeks was identified based on minimizing AIC. R-squares are quite strong, suggesting that these models would be highly effective forecasting one week ahead in sample. However, such predictive power may not hold when iterating the forecast out to the 22 week horizon of the supply and demand model for equitable comparison. While other premiums sometimes have significant effects, typically at least two of the three lags of the dependent variable for each equation are statistically significant and often statistically positive, particularly in the case of the first lag. That is, the premium last week tends to be a positive indicator of the premium this week.

Forecast Performance

For each regression model, coefficient estimates were applied to data from January 2011 to January 2016 to generate out-of-sample forecasts. Table 7 contains results of the Diebold-Mariano test of differences in forecast mean squared error (MSE). Results indicate that MSE for both the supply and demand model and the VAR model are significantly lower than that of the naïve model for all premiums except for the strongly seasonal *Choice-Select* premium, for which the naïve model is more accurate but not significantly so. Notably, no significant difference between the supply and demand model and the VAR model is detected for any premium. Table 8 shows the results of t-tests of differences in forecasts' mean absolute percentage errors (MAPE). These results are mostly qualitatively similar to those presented for MSE in Table 7. The exception is that in terms of MAPE the supply and demand model is significantly better than the VAR model for the *CAB-Choice* premium (p<0.10) and significantly worse than the naïve seasonal model for the *Choice-Select* premium (p<0. 01) but not different from the VAR model (which is not different from the naïve model).

Graphs of premium forecasts and 95 percent confidence intervals along with realized values provide greater insights regarding sources of forecast errors (Figures 2 through 5). For each premium, it is apparent that the naïve model at least partly captures seasonality but fails to reflect trends better represented by other models. Though the supply and demand model initially misses a jump in *CAB-Choice* in 2012, it catches up due to the trend effect, while the VAR model better predicts the 2012 jump but also over exaggerates a subsequent fall in later 2013 before recovering (Figure 3). The supply and demand model also misses jumps in the *Prime–Choice* premium that is logically captured with a lag by the structure of the VAR model (Figure 2). All three models underestimate the amplitude of strong seasonal effects in the *Choice-Select* premium, which may be becoming more variable as choice increasingly reflects only the lower 2/3rd of the grade and upper choice is more often sold as CAB or other branded programs (Figure 4).[3]

Conclusions

We assess the predictive ability of alternative forecasts of weekly beef quality premiums five months out or about the typical duration cattle are fed out in feedlots. A naïve seasonal model is established as a benchmark for comparison with another direct forecast derived from a supply and demand framework and with an indirect forecast derived by iterating predicted values from a VAR model. The analysis stands to contribute to a growing literature debating the relative merits and performance of direct and iterated forecasts under alternative circumstances.

Overall, the results suggest that both approaches—direct forecasts from the supply and demand model and iterated forecasts from the VAR model—outperform a simple, naïve model accounting only for seasonality. However, neither alternative to the naïve model appears to be significantly better than the other for our purposes. Future research may consider whether either of these alternatives encompass the other or if information from both approaches may be combined to make a better forecast.

Endnotes

[1] "It should be noted that about 1.5 to 1.8 points (of a 40 percent increase in CAB acceptance rates from 2006 through 2009) occurred due to the change in the brand's yield grade specifications that went into effect January 23, 2007." (Corah & McCully, 2009, p. 3)

[2] This might be coordinated by cattlemen selling breeding stock, and allowing purchasers of their genetics to bring progeny to "roundups" that accumulate lots of like cattle for feedlots. According to the most recent 2007-2008 United States Department of Agriculture (USDA) National Animal Health Monitoring System (NAHMS) survey, cow-calf producers have been slow to adopt artificial insemination technology, but continue to invest in bulls for natural breeding. On average, a producer will replace almost one-third of the bulls for the herd each year. Thus, producers are able to respond by making breeding decisions (i.e., select sire with expected progeny differences) that most align with current market signals.

[3] "Product sold and reported as USDA Choice is lower quality than it was before branded beef programs. … (T)he commodity Choice boxed beef price, from which the C-S is calculated, does not represent all Choice beef. Rather, the commodity Choice price is the very bottom quality of Choice product that is not sold into a branded program. … When Choice production is seasonally high, it is not uncommon for packers to substitute Choice beef onto their Select orders. … In the reporting process, Choice product gets reported with a Select price." (McCully, 2010, p. 5-6).

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Table 1. Data Sample Collected on a Weekly Basis and Sources

Variable	Series Description	Sample Period	Original Source
P_G	Weekly average quality grade & CAB premiums & discounts ($/cwt)	11/4/1996-1/11/2016	*USDA-AMS report LM_CT155 (Pre-MPR, NW_LS195)*
Q_G	Weekly head marketed by quality grade		
	Weekly U.S. Steer & Heifer Estimated Grading (%)	2/15/1997-1/9/2016	*USDA-AMS report NW_LS196*
	× Weekly U.S. Steer & Heifer Slaughter (1000 head)	2/15/1997-1/9/2016	*USDA-AMS report SJ_LS711*
CARCASS_W	Weekly average dressed weight of steers & heifers (lbs)	11/2/1996-1/9/2016	*USDA-AMS report SJ_LS711*
PLACE_W	Monthly weighted average placement weight (lbs) computed from head placed by weight class	11/1996-1/2016	*USDA-NASS Cattle on Feed report*
CORN	Daily Kansas City corn price ($/bu)	10/31/1996-1/7/2016	*USDA-AMS report SJ_Gr112*
FEEDER	Daily nearby closing feeder cattle futures price ($/cwt)	11/4/1996-1/11/2016	*CME Group*
FAT	Daily nearby closing live cattle futures price ($/cwt)	11/4/1996-1/11/2016	*CME Group*
POP	Annual U.S. population	1997-2016	*USDA_ERS International*
GDP	Annual U.S. real per capita GDP (2010 $)	(2015, 2016 projected)	*Macroeconomic Data Set*

Table 2. Summary Statistics.

Variable	N	Mean	Standard Deviation	Minimum	Maximum
Prime-Choice ($/cwt)	1,002	8.84	3.20	3.69	15.96
CAB-Choice ($/cwt)	1,002	2.39	1.03	0.65	4.99
Choice-Select ($/cwt)[a]	1,002	8.79	4.25	1.22	24.87
Select-Standard ($/cwt) [a]	1,002	10.55	3.21	0.00	19.99
US Population	987	299,000,000	14,700,000	273,000,000	324,000,000
US per capita GDP (2010$)	987	47,441.06	2,890.15	40,920.67	52,953.90
Steer & Heifer Slaughter (1000 head)	987	516.19	51.72	308.26	656.36
Steer & Heifer Dressed Weight (lb)	1,002	792.37	34.75	708.00	888.50
Prime (%)	987	0.03	0.01	0.02	0.07
Choice (%)	987	0.57	0.06	0.48	0.71
Select (%)	987	0.32	0.05	0.19	0.41
Standard (%)	987	0.07	0.02	0.04	0.15
Prime (1000 head)	987	16.20	3.18	7.56	30.20
Choice (1000 head)	987	291.73	24.12	194.94	353.84
Select (1000 head)	987	169.25	36.62	62.44	249.43
Standard (1000 head)	987	39.02	12.37	15.36	79.18
Prime (1000 lb)	987	12,893.09	2,851.95	5838.47	26,791.61
Choice (1000 lb)	987	231,494.80	22,116.72	150,490.70	281,426.40
Select (1000 lb)	987	133,379.80	25,839.77	54,290.69	192,061.80
Standard (1000 lb)	987	30,656.11	8,838.57	12,606.99	59,557.70
KC Corn Price ($/bu)	1,002	3.49	1.74	1.54	8.36
Feeder Futures ($/cwt)	1,002	112.64	39.38	64.10	241.30
Live Cattle Futures ($/cwt)	1,002	93.27	26.72	57.92	171.00
Placement Weight (lb)	1,002	705.29	13.62	673.14	726.79

[a] Converted from discounts (negative values) to premiums (positive values).

Table 3. Naïve Seasonal Model Regression Results.

	Prime-Choice	CAB-Choice	Choice-Select	Select-Standard
Feb	0.1142	-0.1585	-2.0284***	0.7034*
	(0.4027)	(0.1694)	(0.7063)	(0.3995)
Mar	0.1347	-0.1444	-2.2077***	0.5185
	(0.3915)	(0.1646)	(0.6866)	(0.3884)
Apr	-0.1006	0.1600	0.0131	0.1612
	(0.3898)	(0.1639)	(0.6837)	(0.3867)
May	0.0713	0.4500***	2.5531***	-0.4368
	(0.3821)	(0.1607)	(0.6702)	(0.3791)
Jun	0.0630	0.3302**	2.3181***	-0.5027
	(0.3898)	(0.1639)	(0.6837)	(0.3867)
Jul	0.2070	0.0308	0.7424	0.0112
	(0.3850)	(0.1619)	(0.6753)	(0.3820)
Aug	0.3888	-0.1257	0.2124	0.2493
	(0.3850)	(0.1619)	(0.6753)	(0.3820)
Sep	0.6717*	-0.0641	1.1942*	0.0761
	(0.3882)	(0.1633)	(0.6808)	(0.3851)
Oct	0.8165**	-0.0931	2.4648***	-0.2186
	(0.3850)	(0.1619)	(0.6753)	(0.3820)
Nov	0.3932	-0.0528	2.6637***	-0.3823
	(0.3882)	(0.1633)	(0.6808)	(0.3851)
Dec	0.2267	0.0582	2.1075***	-0.4095
	(0.3866)	(0.1626)	(0.6780)	(0.3835)
Constant	7.1243***	2.0042***	7.6505***	9.2251***
	(0.2756)	(0.1159)	(0.4834)	(0.2735)
R^2	0.0153	0.0415	0.1580	0.0293

Notes: *N*=718. One, two, three asterisks (*, **, ***) denote statistical significance at 10%, 5%, 1% levels, respectively.

Table 4. Supply Model Regression Results.

	LN[Prime]	LN[Choice]	LN[Select]	LN[Standard]
Prime-Choice, Lag 117	0.0066**	–	–	–
	(0.0028)			
CAB-Choice, Lag 117	–	0.0119***	–	–
		(0.0029)		
Choice-Select, Lag 117	–	-0.0018***	–	–
		(0.0005)		
Select-Standard, Lag 117	–	–	0.0023	0.0032
			(0.0019)	(0.0043)
KC Corn Price, Lag 22	0.0207**	-0.0068	-0.0287***	0.0078
	(0.0084)	(0.0044)	(0.0052)	(0.0111)
Feeder Futures, Lag 22	0.0008	-0.0014***	0.0021***	0.0037***
	(0.0011)	(0.0005)	(0.0007)	(0.0014)
Live Cattle Futures, Lag22	-0.0071***	0.0002	0.0022**	0.0049**
	(0.0016)	(0.0008)	(0.0010)	(0.0021)
Placement Weight, Lag 22	-0.0011	0.0010*	0.0018***	0.0012
	(0.0010)	(0.0005)	(0.0006)	(0.0014)
Carcass Weight, Lag 22	0.0020***	0.0014***	0.0003	0.0021***
	(0.0006)	(0.0003)	(0.0004)	(0.0008)
LN[t]	-0.1676***	-0.0595***	-0.1785***	-0.4495***
	(0.0351)	(0.0003)	(0.0213)	(0.0453)
≥2000 Dummy	0.1984***	0.0365***	0.1065***	0.1633***
	(0.0291)	(0.0139)	(0.0176)	(0.0372)
≥2007 Dummy	–	0.0884***	–	–
		(0.0075)		
Constant	9.7218***	10.8750***	10.9013***	9.4551***
	(0.7598)	(0.3791)	(0.4586)	(0.9713)
R^2	0.3892	0.4744	0.6232	0.3582

Notes: *N*=622. One, two, three asterisks (*, **, ***) denote statistical significance at 10%, 5%, 1% levels, respectively. The term Lag represents weeks the variable was lagged in the model.

Table 5. Demand Model Regression Results.

	Prime-Choice	CAB-Choice	Choice-Select	Select-Standard
LN[Prime]	-1.0196**	-0.9071***	–	–
	(0.4153)	(0.2081)		
LN[Choice]	-0.3661	1.9968***	-20.0948***	–
	(0.9019)	(0.4675)	(1.5288)	
LN[Select]	–	–	21.9501***	-6.0822***
			(1.4061)	(0.8453)
LN[Standard]	–	–	–	-0.8762**
				(0.3679)
US Population	1.2700×10^{-8}	-9.8900×10^{-9}	2.3200×10^{-7}***	1.4700×10^{-7}***
	(1.4600×10^{-8})	(7.8900×10^{-9})	(4.1700×10^{-8})	(1.7400×10^{-8})
US per capita GDP	0.0007***	0.0003***	-0.0003**	-0.0007***
	(4.6800×10^{-5})	(2.5400×10^{-5})	(1.3740×10^{-4})	(6.9900×10^{-7})
LN[t]	-0.8383***	-0.1174*	0.6061**	-0.0505
	(0.1211)	(0.0657)	(0.2892)	(0.1780)
≥2000 Dummy	-0.3371*	-0.0748	-1.9454***	-0.2527
	(0.1875)	(0.1017)	(0.4543)	(0.2645)
≥2007 Dummy	2.0250***	0.4089***	-1.6472***	–
	(0.1893)	(0.1010)	(0.4163)	
Constant	-10.0339	-23.4369***	-58.6909***	79.4722***
	(8.6124)	(4.5915)	(20.9181)	(11.1591)
R^2	0.7620	0.6035	0.5675	0.4570

Notes: *N*=622. One, two, three asterisks (*, **, ***) denote statistical significance at 10%, 5%, 1% levels, respectively.

Table 6. VAR Model Regression Results.

	Prime-Choice	CAB-Choice	Choice-Select	Select-Standard
Prime-Choice, Lag 1	0.7251***	-0.0023	0.0199	0.0280
	(0.0376)	(0.0240)	(0.0745)	(0.0741)
Prime-Choice, Lag 2	0.2424***	0.0547*	0.0088	-0.0085
	(0.0452)	(0.0288)	(0.0896)	(0.0891)
Prime-Choice, Lag 3	0.0119	-0.0217	-0.0111	-0.0129
	(0.0374)	(0.0239)	(0.0741)	(0.0737)
CAB-Choice, Lag 1	-0.0257	0.8111***	0.4926***	-0.3832***
	(0.0583)	(0.0372)	(0.1156)	(0.1149)
CAB-Choice, Lag 2	-0.0606	0.1525***	-0.1374	0.2264
	(0.0742)	(0.0473)	(0.1470)	(0.1462)
CAB-Choice, Lag 3	0.1214**	-0.0580	-0.4088***	0.1733
	(0.0588)	(0.0375)	(0.1165)	(0.1158)
Choice-Select, Lag 1	0.0883***	0.0359***	1.2301***	-0.1846***
	(0.0190)	(0.0121)	(0.0376)	(0.0374)
Choice-Select, Lag 2	-0.0950***	0.0240	-0.0390	0.0343
	(0.0305)	(0.0195)	(0.0604)	(0.0601)
Choice-Select, Lag 3	0.0163	-0.0598***	-0.2443***	0.1340***
	(0.0193)	(0.0123)	(0.0382)	(0.0380)
Select-Standard, Lag 1	0.0619***	-0.0025	0.0478	0.5578***
	(0.0192)	(0.0123)	(0.0381)	(0.0379)
Select-Standard, Lag 2	-0.0125	-0.0094	-0.0633	0.1931***
	(0.0222)	(0.0142)	(0.0440)	(0.0438)
Select-Standard, Lag 3	-0.0351*	0.0084	-0.0207	0.1852***
	(0.0194)	(0.0124)	(0.0384)	(0.0382)
Constant	-0.0282	0.0369	0.4215	0.6843***
	(0.1345)	(0.0858)	(0.2666)	(0.2651)
R^2	0.9729	0.9393	0.9704	0.8946

Notes: *N*=716. One, two, three asterisks (*, **, ***) denote statistical significance at 10%, 5%, 1% levels, respectively. The term Lag represents the number of weeks the variable was lagged in the model.

Table 7. Diebold-Mariano Test of Forecast MSE, Where each set of comparison is in matrix notation for a particular quality grade.

		Naïve (Seasonal) Model	VAR Model	Difference
P-C	MSE	26.38	3.16	23.22***
	S&D [lbs]	3.82	3.82	
	Difference	22.56***	-0.66	
CAB-C	MSE	1.73	0.24	1.49***
	S&D [lbs]	0.17	0.17	
	Difference	1.56***	0.07	
C-S	MSE	13.21	16.67	-3.46
	S&D [lbs]	15.01	15.01	
	Difference	-1.79	1.66	
S-S	MSE	25.81	5.11	20.70***
	S&D [lbs]	5.16	5.16	
	Difference	20.65***	-0.05	

Notes: All statistics are reported as $/cwt. One, two, three asterisks (*, **, ***) indicate differences statistically significant at 10%, 5%, 1% levels, respectively.

Table 8. T-Test of Differences in Forecasts' Mean Absolute Percentage Error, Where each set of comparison is in matrix notation for a particular quality grade.

		Naïve (Seasonal) Model	VAR Model	Difference
P-C	MAPE	36.96	10.71	26.25***
	S&D [lbs]	11.53	11.53	
	Difference	25.43***	-0.82	
CAB-C	MAPE	34.74	10.35	24.39***
	S&D [lbs]	9.15	9.15	
	Difference	25.59***	1.20*	
C-S	MAPE	33.46	34.69	-1.23
	S&D [lbs]	36.96	36.96	
	Difference	-3.50***	-2.27	
S-S	MAPE	30.55	12.83	17.72***
	S&D [lbs]	13.21	13.21	
	Difference	17.34***	-0.38	

Notes: All statistics are reported as $/cwt. One, two, three asterisks (*, **, ***) indicate differences statistically significant at 10%, 5%, 1% levels, respectively.

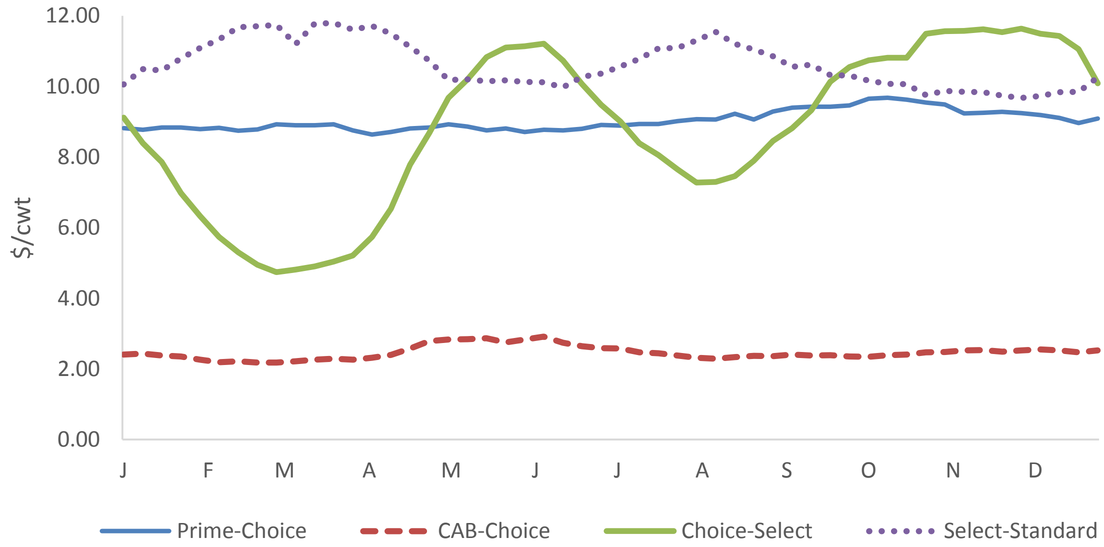

Figure 1. Seasonality in Beef Grade and CAB Premiums

Naïve Model | Supply & Demand Model | VAR Model

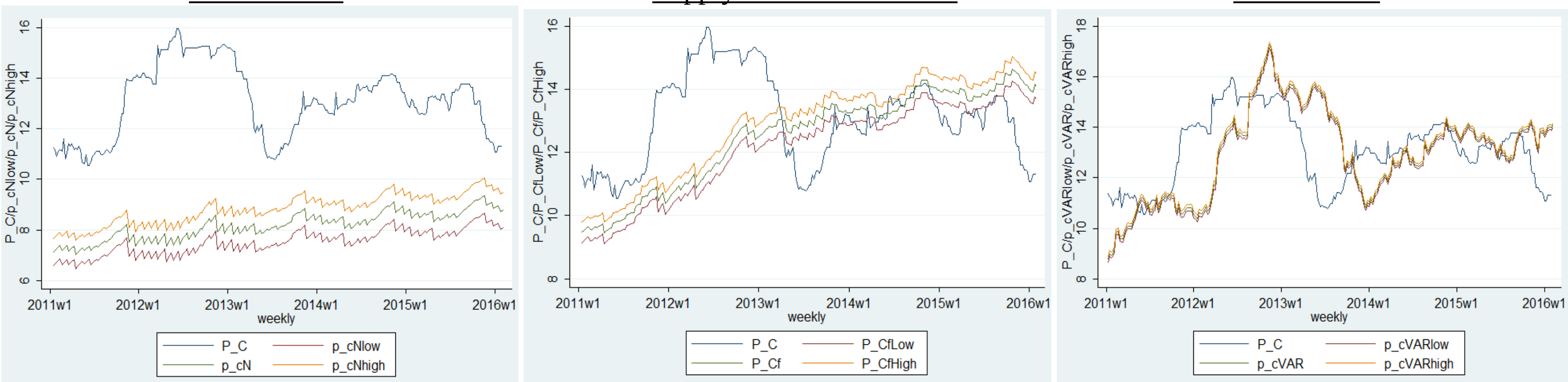

Figure 2. Prime-Choice Forecasts

Naïve Model | Supply & Demand Model | VAR Model

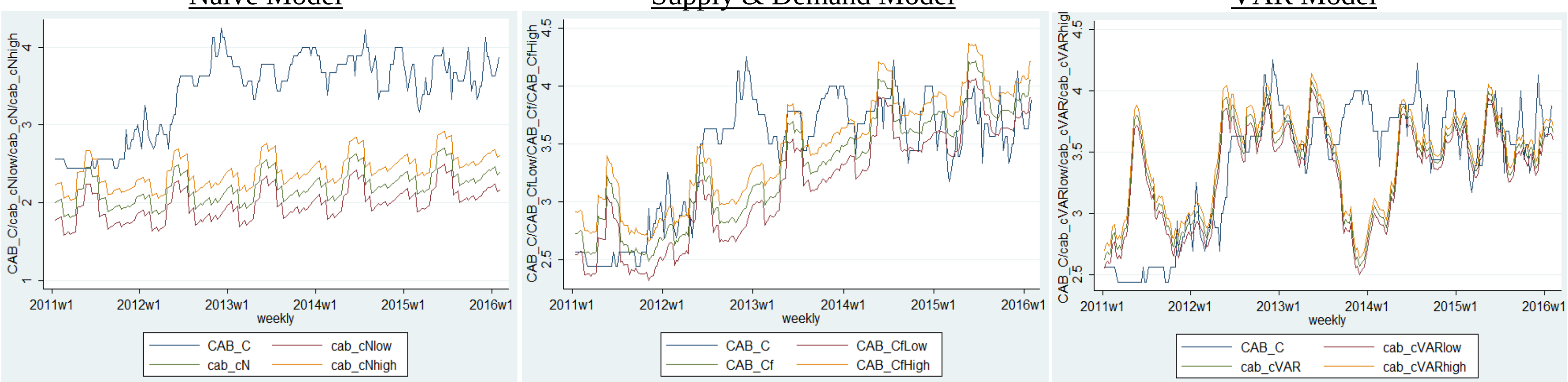

Figure 3. CAB-Choice Forecasts

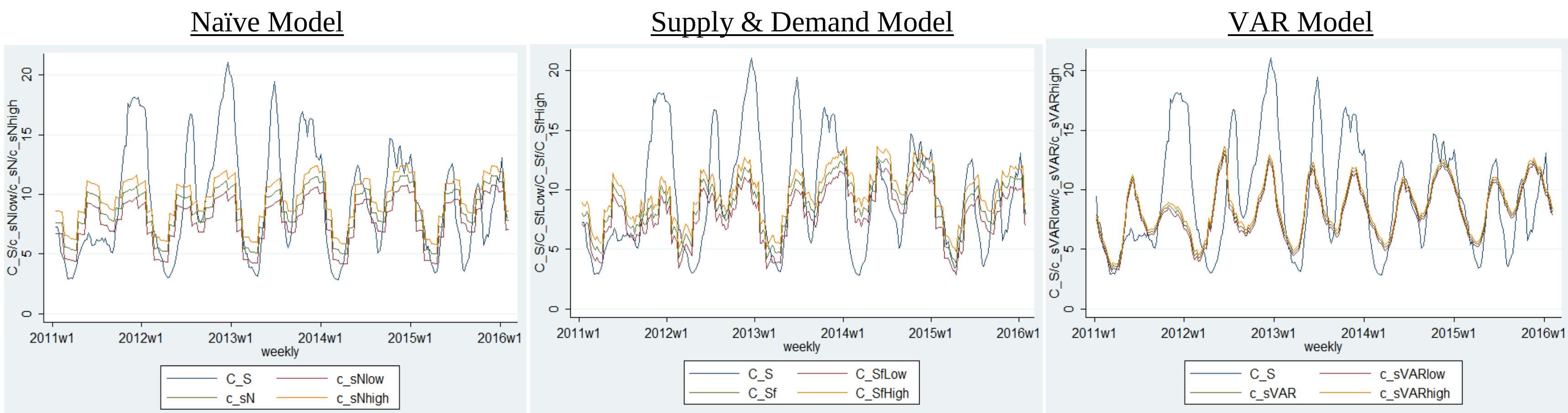

Figure 4. Choice-Select Forecasts

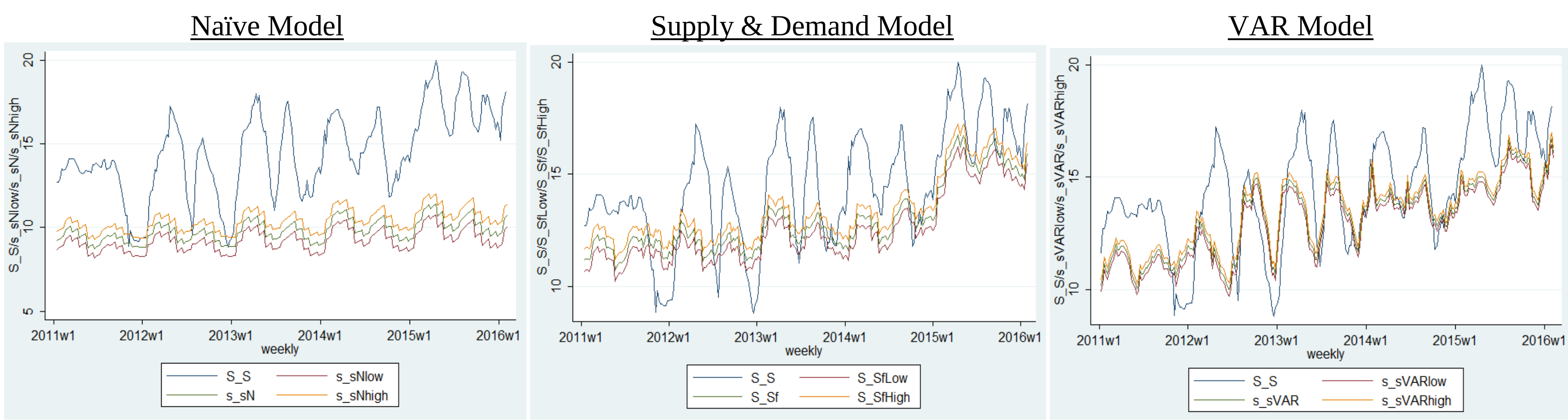

Figure 5. Select-Standard Forecasts