COMMODITY PORK PRICE FORECASTING FOR HORMEL FRESH PORK SALES TEAM

by

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B.S., Kansas State University, 2007

A THESIS

Submitted in partial fulfillment of the requirements

for the degree

MASTER OF AGRIBUSINESS

Department of Agricultural Economics

College of Agriculture

KANSAS STATE UNIVERSITY

Manhattan, Kansas

2011

Approved by:

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ABSTRACT

To remain competitive in an ever changing pork industry, Hormel Foods required careful evaluation of advertising forecast accuracy. This study determines forecasting accuracy for bone-in loins, boneless loins, butts, and ribs pricing within Hormel Foods and determines the relationship between forecast horizon (how many weeks forward in pricing) and forecasting accuracy of these products. The challenge required the data collection of the advertising pricing quotes for the sale price in comparison to the forecasted price. Several different forecasting combinations were examined to determine the ideal combination.

The focus of this research was to determine which forecast or combination of forecasts was preferable for Hormel Foods. Findings include that each commodity and weeks out front have a different preferred forecast or combination of forecasts when analyzing root mean square errors. Four forecasts (three forecast companies and the United States Department of Agriculture actual markets at the time of forecasts) were observed with one forecast company rarely utilized in the preferred forecasting combinations and therefore the potential exists for a cost savings that affect the bottom line profitability of the division. In addition, economic models presented in this study explain the errors (both raw and percentage based) in relation to the forecast companies, weeks out front forecasted, and specific commodity differences.

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ACKNOWLEDGMENTS

I would like to acknowledge my husband who patiently put his life on hold and encouraged me to achieving my goal of completing my thesis. I would also like to thank all the people I have worked with over the past couple of years who have patiently allowed me to ask questions and taught me so much. I would like to acknowledge my major professor Dr. Glynn Tonsor and my committee Dr. Crespi and Dr. Schroeder. In addition, I would like to thank Hormel Foods for allowing me the opportunity to complete this program, and the USDA for providing me with historic pricing data. Finally, I would like to acknowledge Lynnette Brummett, Mary Bowen, and Dr. Featherstone for guiding my studies through the Masters of Agribusiness program.

CHAPTER I INTRODUCTION

Hormel Foods would like to determine if the current forecasting tools provided to the National Accounts Managers are relevant in gaining or losing margin. The objectives of this study include determining forecasting accuracy for bone-in loins, boneless loins, butts, and ribs pricing within Hormel Foods. An additional objective of the thesis is to determine the relationship between forecast horizon (how many weeks forward in pricing) and forecasting accuracy of bone-in loins, boneless loins, butts, and ribs Hormel Foods pricing. Currently Hormel Foods uses forecasting tools with up to six week horizons (however only issues firm quotes up to four weeks), but the relevance in gaining or losing margin is yet to be examined.

Hormel Foods fresh pork sales division employs 20 individuals directly responsible for forecast accuracy in retail fresh pork advertising quotes. These twenty employees are responsible for forecasting 300 million dollars of gross sales annually for the bone-in loin, boneless loin, butt, and rib commodities. Therefore, the accuracy of the forecasts utilized to quote customers is essential for sales dollars and maintaining a positive reflection on the customer score card. Our customers rely on our knowledge and accuracy in market forecasting to remain competitive in a very fast paced pork industry.

With the dollar value associated, forecasting is important to the bottom line profit of Hormel Foods, therefore this is a very beneficial analysis to conduct. The sales force needs all resources necessary in forecasting to obtain the highest possible margins for the company and minimize losses. Current forecasting tools provided to the staff include over $400,000 in annual costs. Therefore, if one or more is not accurate a cost savings would be beneficial not only in the cost savings of the forecasting company, but also in the savings of lost margin from inaccurate forecasts.

Hormel Foods employs seven National Accounts Managers along with a manager for these seven individuals to price commodity pork to the retail pork industry including key program accounts and have accurate pricing. The National Accounts Managers require

accurate forecasting tools to assure they can quote the most accurate advertised pricing as far as six weeks out. If the Hormel Foods current forecasting tools are insufficient, more research and time will need to be put forth to achieve more accurate forecasting to improve bottom line dollars for the company.

Using five key Hormel Foods accounts, we gathered all advertised pricing from fiscal year 2009 weeks 26-52 and fiscal year 2010 weeks 1-26. In addition, we obtained all advertized prices for each commodity during this time frame versus the market pricing for the same ship dates. Once all data was obtained for all advertisements, the first step was to separate the data out into the four commodities. Then comparison began with market differences and swings.

The information to meet the thesis objective was within the Hormel pricing and invoicing system. In addition, the utilization of USDA daily market closes was obtained out of the Hormel archives.

CHAPTER II LITERATURE REVIEW

2.1 The economic impact of price forecasting for companies

Outside of education, economic research on market forecasting is rarely utilized as businesses arguably rarely directly use this research. The attributing factors include research approaches unrealistic to the business world and the need to be adapted to begin with small gains in the business world. The data in many past studies utilize public data which may lack detail to obtain strong conclusions for individual firms. New theories are being developed and used to push current research forward for business use (Brorsen 1996).

Large meat companies rely on price forecasting from the USDA for profitability. When price fluctuates at unpredictable levels, company risk is increased and potential for losses or gains exist. The market futures prices and forecasting of these futures prices are critical in all decisions for firms. USDA market futures price forecasts have been found to be unbiased for hogs and cattle, but not in the broiler industry. In addition, USDA forecasts show inefficiencies in that forecast errors are continually repeated. However, USDA does efficiently forecast hog futures prices in time series. However, over time hogs have been more complicated to determine trends. This is due to the structure changes in the hog industry towards vertical integration. Overall, USDA market future price forecasting is very good with the chance to improve some bias from some price forecasting. Another note is that USDA price forecasts are no more accurate over 20 years of forecasting from 1982 to 2002. However, these USDA pricing forecasts can be used in combination with private forecasting firms to improve general company forecasts (Sanders 2003).

Price forecasting places attention on price differences in relation to seasonal changes. Moreover, attention needs to be paid to both long and short run forecasts versus one or the other. Using the combination of both long and short run forecasts provide academics and businesses with an increase of tools for accurate forecasting. Forecast consistency relies on variables remaining relatively close together, and a long history of the variable to be forecasted. Forecasting errors often cycle back to the same error over and over again as bias and inconsistency exists. The USDA adjusts forecasts quickly to short run deviations from

the long term forecast, but challenges do arise as information is left out from prior forecasts and pricing errors. Repetition of errors is prevalent in hogs, egg, and milk according to Sanders and Manfredo. Even though the errors exist in forecasting, creating and utilizing them is a huge task for accuracy. Forecasting must be understood in the terms of long and short run forecasts and the variation and differences possible with both (Sanders 2007).

In further comparison of USDA forecast accuracy, Kastens, Schroeder, and Plain review Extension and USDA price and production forecasts. In broad terms, extension forecasts are more correct than USDA for livestock; however the USDA tends to be more correct on crops. Composite forecasts tend to be more correct than extension or USDA alone. Due to client needs, extension can be more accurate at times as they are aware of the needs and forecast accordingly. The decision to use a forecast needs to be weighed by the individual client to determine the most accurate forecast for their application. Another issue that arises when using extension and private forecasting is cost effectiveness. USDA does not always have forecasts readily available to the public, but private forecasts use the USDA data along with other data to create their own forecast at a cost. If forecasting costs can be reduced while increasing accuracy, the forecast should be explored. In terms of forecasting accuracy, five key points were observed and documented by Kastens in "Evaluation of Extension and USDA Price and Production Forecasts". These points included: experience doesn't improve accuracy, government and private forecasters are no more or less accurate than universities in livestock, but have a slight crop advantage, Ph.D. forecasters are only slightly more accurate than those without a Ph.D., formal models do not appear to increase forecasting accuracy, and those who view forecasting as a major part of their job are more accurate than those who casually forecast (Kastens 1998).

2.2 Forecast combinations versus single forecasts

Price forecasting for one commodity relies on the comparison to direct and cross-commodity pricing as well to determine true variation. Consumer demand of products is based on budgeting versus on wellness. Price changes can turn a consumer to another product. Studying the multiple effects of price changes is broader in the differences in consumer preferences versus price alone and competing prices. The consumer pricing on

the contrary does not account for the supply chain of livestock immediately in terms of changing the supply and demand curve until surplus or shorts occur which can be a lag of days, weeks, months, or years depending on the product, but rather each supply and demand curve is independent causing pricing and margin issues (Huang 1993).

Price risk management is essential in forecasting. The level of risk ultimately equals the level of failure or reward. The optimal forecast time line is also essential. The number of weeks, months, or years to use depends upon the time frame to be analyzed. In feeder calf basis forecasting, a three year historic average is typically used and a four year average in live cattle basis to determine the most realistic results. In addition to the historical average, livestock forecasts use eight to twelve week current basis information and add that information into consideration to improve accuracy. Forecasters who use the best multiyear average and the perfect amount of current information are likely to experience a more accurate basis forecast (Tonsor, Dhuyvetter, and Mintert 2004).

International commodity prices over time experience the most highs and lows in terms of market swings. Some of the time, the ups and downs experienced are greater than that of exchange and interest rates. The majority of these price swings can be attributed to fluctuations in supply and/or demand. These swings create challenges for long term price forecasting. Systematic analysis using different categories including derived option price expectations, time series models, and the combination of both were used in this study. Most forecasts of commodity prices use option prices or time series models. However, a combination of these two has increased accuracy in market forecasting (Clauessens 1993).

2.3 Forecast accuracy in relation to horizons

Price forecasting for the commodity beef market is behind in terms of printed work. However, efficient market hypothesis use more components to forecast more effectively. Relationships observed include hedgers both long and short term, net short speculators, and finally the consumer. The observation yielded the possible presence of non-linearity in two of the models, long hedging and net short speculation. While these two equations illustrated

non linearity, functional relationships did exist in short hedging, net short speculating, consumers, and the spot buying equations (Goss 2001).

By monitoring daily, weekly, and annual price fluctuations of futures markets for frozen pork bellies it is determined that trader profits over fixed periods are not random but rather determined by the anticipation of market fluctuations in historic data. The differences in price fluctuation and profits/losses also rely heavily on the type of trading being conducted whether it is short run or long run trading along with excellent or poor forecasting, influence of market shares, and/or pure luck. Short run trading using forecasts is dependent on the individual forecasts used or combination of forecasts and can vary due to market peaks and valleys. Whereas, long run trading takes into account more long term market conditions and if traders use good forecasts and can read these well, the opportunity for great gains are possible. Ultimately, the profits/losses traders experience are dependent on the accuracy of forecasting and ability to predict large market swings both in long and short run forecast and take large risks immediately prior to the predicted price fluctuations (Leuthold 1994).

The use of multiple forecasts as discussed above can benefit the accuracy of the forecast. In addition, the timelines used in these forecasts also benefit accuracy. It is essential to understand forecasts used in a composite forecast and the timelines used to determine potential accuracy across forecasts. Generally in the livestock industry, forecasts are several quarters ahead on live contracts due to the time required to breed, raise, and finish the final product. Typical forecast accuracy decreases with the length of time, however forecast accuracy varies as much as two percent in the USDA, Extension, and Time Series data in three different forecasting models. Therefore, the use of a composite forecast is the most accurate for long term as the time interval increased the ability to accurately forecast tends to decrease (Sanders 2004).

CHAPTER III THEORY

The benefits of forecast accuracy to Hormel Foods include both accuracy to enable our customers to set more aggressive advertising prices, as well as maintaining a bottom line profit margin for the division of the company. Customers set advertising banners as early as four weeks before an advertising circular, and therefore need to have an accurate price. Our accuracy allows the customer to be successful by setting aggressive yet profitable advertised prices to compete against several other grocery store and/or discount chains. The more accurate Hormel's advertising quotes can be further out front, the more confidence the customer has as well as the more margin gained by Hormel Foods. The less accurate Hormel's advertising quotes, the less confidence the customer has and the loss of margin by Hormel Foods.

3.1 Forecast accuracy decreases over time

Forecasting accuracy tends to decrease over time. Sanders and Manfredo suggest short term forecasts are more accurate than long term forecasts. Their study illustrated forecasted pork prices three quarters out measured per quarter. Each quarter out decreased in accuracy in each tested forecast including USDA, Extension, and Time Series for tests that included root mean squared error, mean absolute error, and Theil's *U*. Sanders and Manfredo also tested the composite forecast accuracy versus single forecasts and determined in most cases the composite forecast increased accuracy.

There are several factors that affect forecast accuracy including time horizon, data availability, level of aggregation, product type, and stability. A number of studies indicate that forecast accuracy decreases over time. Schnaars utilized six different forecasting methods over a five year span with different sample sizes. His results indicate decreasing forecast accuracy each year using mean absolute percentage errors through the different forecasting methods.

Norwood and Schroeder examined beef price forecasting comparing one month forward to six months forward pricing using placement-weight data of the cattle on feed.

Improvements over the six months were limited except month three was better over month four so improvement was only significant month over month not long term (Norwood and Schroeder 2000).

3.2 Hormel decision trees of forecast timeline

To determine which forecasting method is the most accurate, Hormel will utilize a decision tree. Since there are so many options of forecasting including forecast combinations, products, and time between forecast and sale, utilizing a decision tree provides a visual approach to view the options available. A decision tree is broken down into four key parts which include acts, events, outcomes, and payoffs in accordance with Southern Illinois University Edwardsville's, "A very fast intro to decision theory". The first part is the acts which are the options being considered by Hormel. In Hormel's case, the act is the choice of the forecast company. The events are the options taken beyond the control of Hormel. In Hormel's case, the events are the individual commodity selected as the advertised item. The outcomes are the end result of the occurrence whether positive or negative. In Hormel's case, the outcomes are the results occurring two weeks out, three weeks out, or four weeks out. The payoffs are the weight based on outcome that Hormel places on each result. The payoffs can be positive or negative as are the outcomes. In Hormel's case, the payoffs are blanketed as the results of gross margin at each level of the outcomes. Ultimately in Hormel's case, the outcome and payoff will be in the same box of the decision tree. The payoff will be further determined upon the completion of all analysis.

The visual drawing of the acts, events, outcomes, and payoffs is deemed a decision tree. Figures 3.1-3.5 illustrate the different options the decision tree can present related to the thesis objective. To further explain, Figure 3.1 starts with the Customer Requested Advertisement Pricing. At this point, the customer corresponds with the national accounts managers to determine the advertising price to set. Next, the national accounts managers acquire data from forecasting companies and USDA and use individual forecasts and/or combinations of forecasts which vary figure to figure. However, in Figure 3.1 the forecasts presented are Company A, Company B, or Company C. The next step in viewing the figure is the commodity being considered being ribs, butts, loins, or boneless loins. Once that is

determined the national accounts managers can view the results of the study to determine how far out front or nearby to remain and which forecast combination to use in relation to the forecast accuracy determined by the data presented.

With the vast number of forecasts available and the combinations which can be created, the following figures clearly illustrate the options in relation to an ending payoff for each act, event, outcome, and payoff. This shall allow for better decisions to be made as all variables are clearly outlined. The decision will ultimately lie in the hands of Hormel Foods, to make the most profitable decision for the company based on all results of the decision tree as well as the consumer demand.

Figure 3.1: Customer Advertising Decision Tree—Individual Forecast Companies

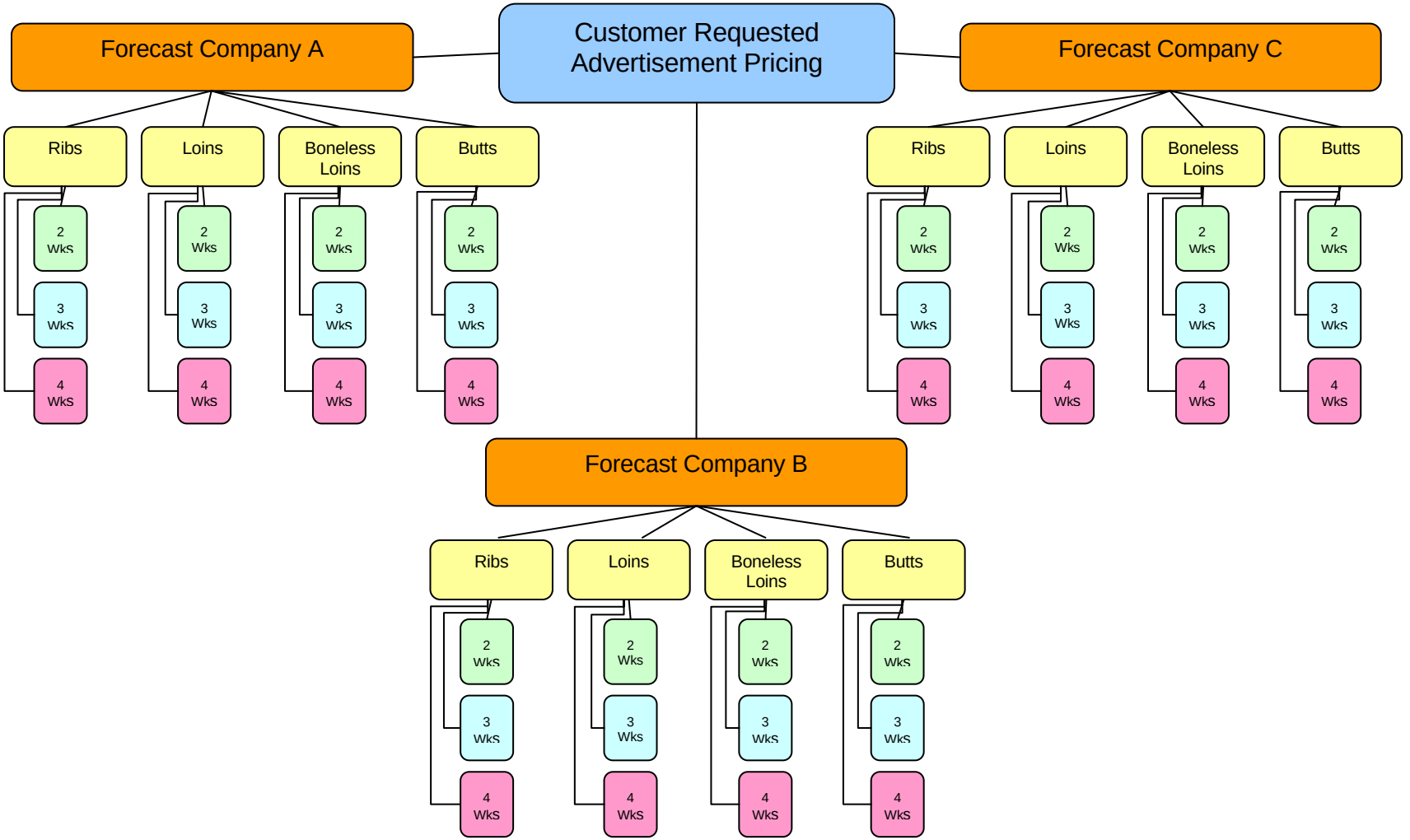


Figure 3.2: Customer Advertising Decision Tree—Individual Companies plus Current USDA

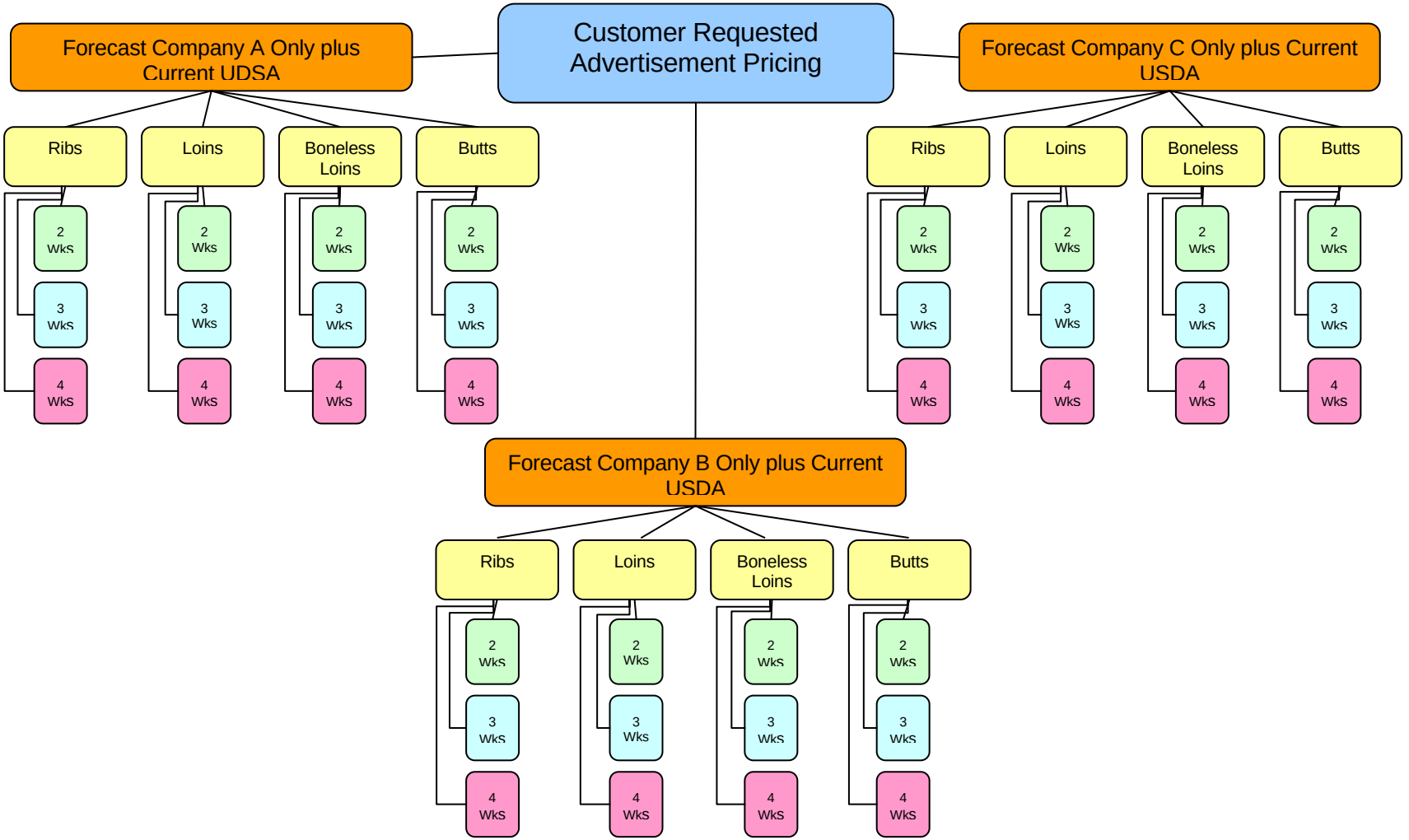


Figure 3.3: Customer Advertising Decision Tree—Individual Company Composites

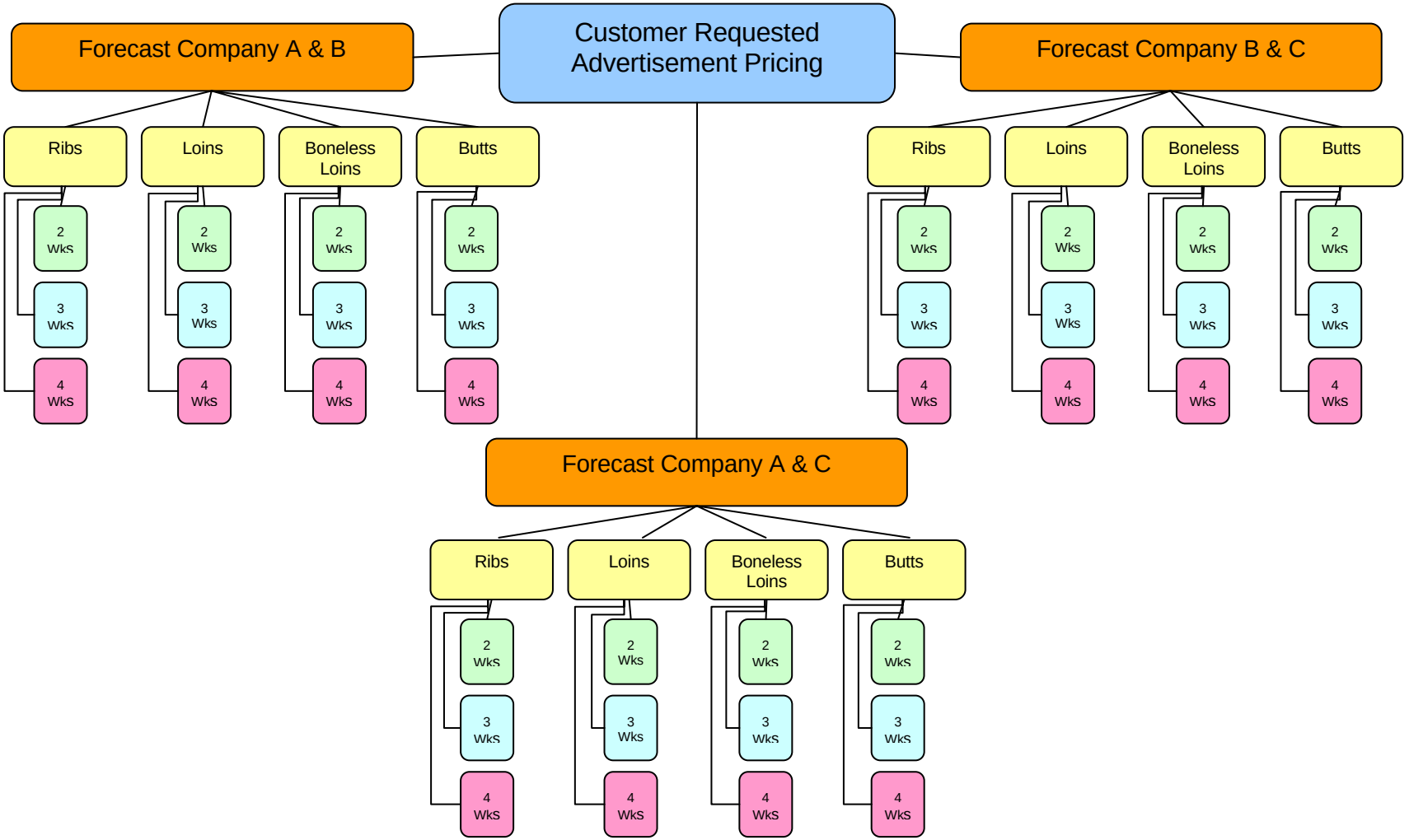


Figure 3.4: Customer Advertising Decision Tree—Individual Company Composites plus Current USDA

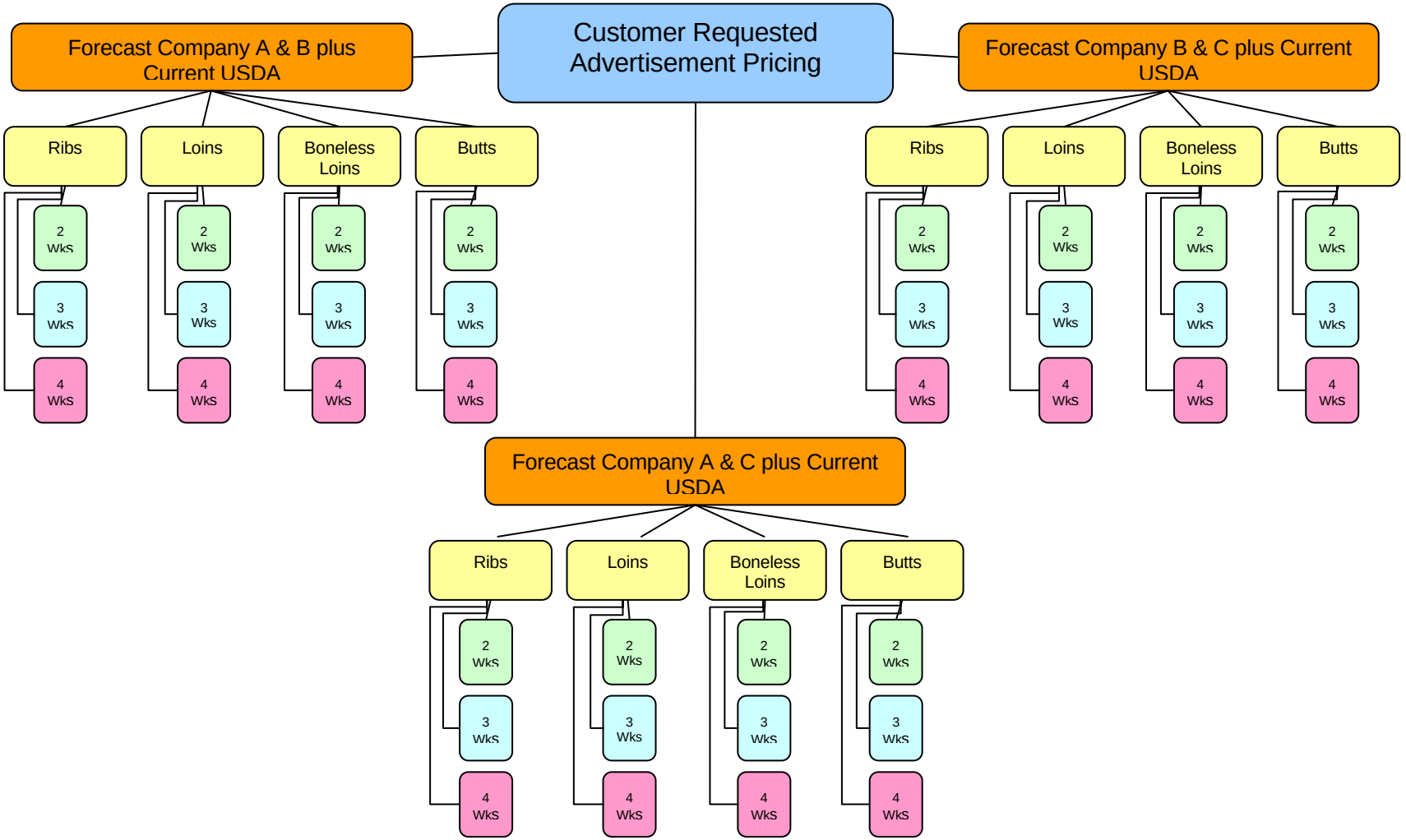
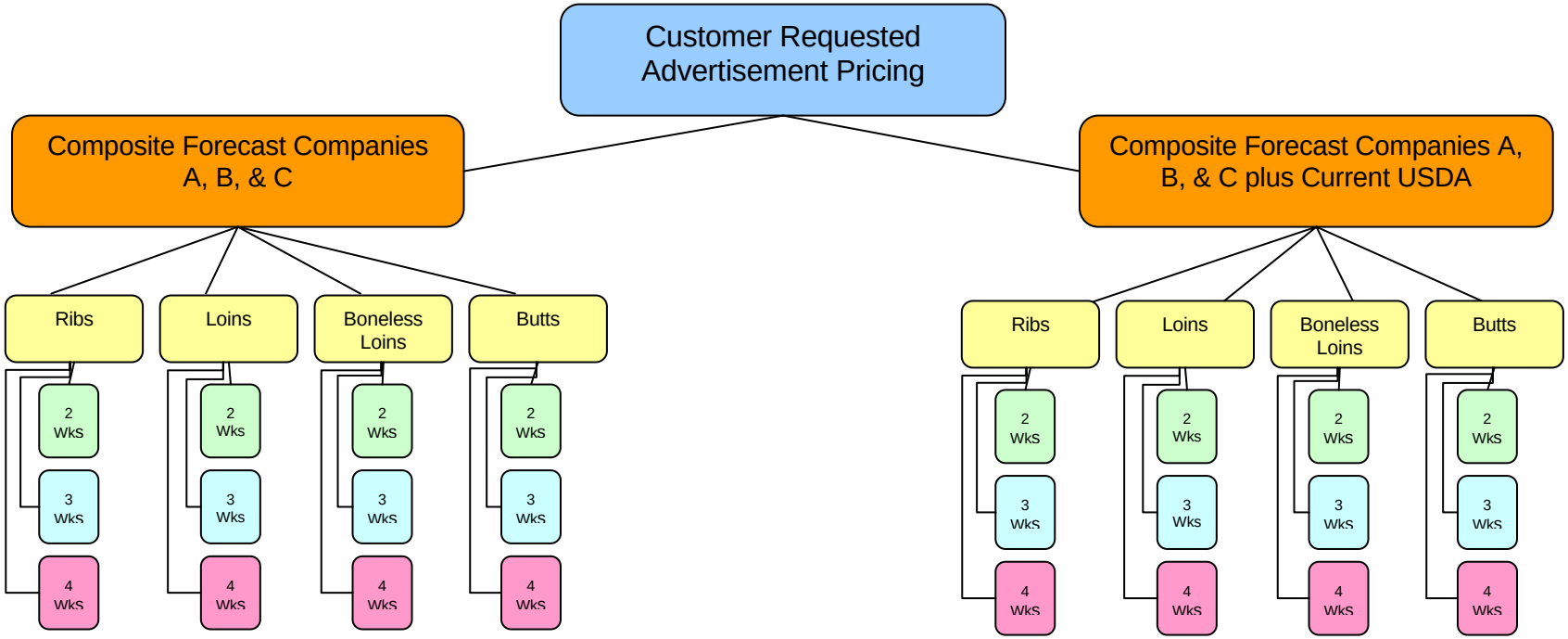


Figure 3.5: Customer Advertising Decision Tree—Composite Forecasts: All companies plus USDA



CHAPTER IV METHODS

The collection and analysis of data was obtained from Hormel Foods internal sources and analyzed.

4.1 Data Acquisition

The Hormel Decision Support (HDS) system provided sales data to the Hormel marketing and sales divisions for past and future sales. Using five key Hormel Foods accounts, we gathered all advertising pricing from fiscal year 2009 weeks 26-52 and fiscal year 2010 weeks 1-26. To determine advertising data versus weekly flow business (typical quantity purchased weekly), only quantity increased over normal sales were captured. Only the advertising quantities were utilized as those sales are priced from the forecast quoted price versus normal flow business is priced from a weekly or daily price list depending on the customer for that week's business derived from the current week's USDA reported sale prices. Therefore, each customer has a variable quantity based on their normal weekly volume. This variable quantity directly relates to the sample sizes of each commodity and customer. For example, customer nubmer1 forecasted two weeks out front, customer number 4 forecasted four weeks out front, and customer number two, three, five, and six were forecasted three weeks out front. This creates a greater frequency of advertised prices and increased sample size for three weeks out as more customers were quoted at three weeks. Table 4.1 illustrated the minimum tonnage used for each account and commodity.

Table 4.1: Advertising Minimum Quantities (lbs) Used

Advertised Commodity	Customer # 1	Customer # 2	Customer # 3	Customer # 4	Customer # 5	Customer # 6
Bone In Loins	100,000	not sold to customer	175,000	100,000	30,000	5,000
Boneless Loins	70,000	150,000	90,000	50,000	30,000	20,000
Steak Ready Butts	70,000	100,000	130,000	40,000	10,000	30,000
Spare Ribs	40,000	not sold to customer	50,000	30,000	30,000	not sold to customer

After gathering freight on board (FOB) pricing for all advertising sales, the sales were separated by the number of weeks out front of the sale the price quote was given. Hormel Foods provides ceiling prices that were the maximum for the customer to lock in an advertising circular two, three, and four weeks prior to the shipping week. These prices would be reduced if appropriate by the National Account Managers if the market weakened. However, if the market strengthened, the price remained at the ceiling price.

The next step was to calculate a weekly average for the USDA price for each week. The data were obtained from the USDA reporting office. The weekly average was calculated for each Monday through Friday top side close. If commodity remained untraded for the day, we used the prior day's close. Hormel uses top side USDA pricing for the majority of its customers when setting prices and overages. Therefore, the top side averages were used versus other types of USDA pricing such as weighted average or low side average. The bone-in loin commodity used was ¼" Trim 21#DN-LGT. The boneless loin commodity used was LOINS, CNTRCUT, 10-11 RIB, ¼" TRIM BNLS Strap-off 5-11#. The butt commodity used was ¼" TRM 5-10#. The rib commodity used was 3BAG/3 PCVAC4.25#/DN-LGT. The USDA further describes each of these commodities upon request as noted on the USDA Market News USDA National Carlot Pork Report 500. Standard Hormel Foods overages were then applied to bone-in loin and butt commodity market price.

Forecast companies and USDA data were obtained from three individual companies and the USDA Market Close reports. Data were gathered for the correct ship week. At that point, forecast errors were calculated for the variety of forecast and composite forecast options for each commodity advanced quote as well as each forecast option. See Tables 5.1-5.12 for each specific commodity at each forecasted week out front forecast errors along with Root Mean Squared Error (RMSE) calculation. The tables indicate the forecast or forecast combination used in the first column titled Forecast. These forecast combinations or single forecasts represent all available data Hormel managers have access to. The next four columns represented the summary statistics for each of these forecast data sets included mean, standard deviation (St. Dev.), minimum, and maximum.

The expectation was that combinations of forecasts will provide more accurate forecasting as reflected in lower RMSE values. The raw forecast of USDA at forecast would be expected to have the highest RMSE as it was not using any forecasting but rather data already available.

4.2 Data Analysis

Root means squared error (RMSE) was calculated and is identified in Tables 5.1-5.12 to use in determining the most preferred forecast in terms of accuracy. Each sample which varied in size however, the calculation was the square root of the sum of squares divided by the sample size. The lower the RMSE the more ideal the forecast therefore, each commodity and time frame differ for the preferred forecast. The expectation would be that the more forecasts used, the more accurate the forecast therefore the average of the USDA at forecast, company A, company B, and company C would yield the most accurate forecast.

To further test which forecast method was most accurate on a raw error basis and percentage based error, the models given in (1) and (2) were estimated:

(1) $E = \beta_0 + \beta_1 Forecast\ A + \beta_2 Forecast\ B + \beta_3 Forecast\ C + \beta_4 WeeksOut + \beta_5 Ribs + \beta_8 Steak\ Ready\ Butts + \beta_{11} Bone\ In\ Loins + \varepsilon.$

(2) $\%\ E = \beta_0 + \beta_1 Forecast\ A + \beta_2 Forecast\ B + \beta_3 Forecast\ C + \beta_4 WeeksOut + \beta_5 Ribs + \beta_8 Steak\ Ready\ Butts + \beta_{11} Bone\ In\ Loins + \varepsilon.$

E was the raw data forecast error; *% E* was the percentage based forecast error, *Forecast A* was a dummy variable for the specific forecast A (1 if Forecast A, 0 if Forecast B or C), *Forecast B* was a dummy variable for specific forecast B (1 if Forecast B, 0 if Forecast A or C), *Forecast C* was a dummy variable for specific forecast C (1 if Forecast C, 0 if Forecast A or B) all in relation to the USDA, *Weeks Out* was a variable for how many weeks prior to the sale the price was given (two, three, or four weeks), *Ribs, Steak Ready Butts, and Bone In Loins* were dummy variables (1 if the forecast error was from that particular commodity, 0 if the forecast error was not the particular commodity) all in

relation to boneless loins. The *E*, raw error, term was calculated by subtracting the FOB sale price from the USDA FOB price on the sale date of the commodity. The *% E*, percentage based error, term was calculated by subtracting the FOB sale price from the USDA FOB price on the sale date, and then divided that value by the FOB sale price and multiplying by 100.

The expected coefficient signs were the same for both equation (1) and (2). In the experience of the national accounts managers which accounted for over 150 years of combined experience, Forecast A was expected to be negative as it is typically lower than the USDA market. Forecast B and C were expected to be positive as they are typically above the USDA market. Weeks out variable had no expected sign as forecast error typically increases further out front but the effects are unknown positively or negatively. The rib commodity was expected to be negative as the commodity had a higher value with more built in company margin as quoted prices were typically higher than the forecast company suggestions due to the limited production internally at Hormel. Butts and bone-in loins commodities were expected to be positive as the commodities have lower base value and therefore any forecasting error had a lower likelihood of being absorbed in the forecast price.

To further test which forecast method was most accurate for individual commodities on a raw error basis and percentage based error, the models given in (3) and (4) were estimated:

(3) $$E = \beta_0 + \beta_1 Forecast\ A + \beta_2 Forecast\ B + \beta_3 Forecast\ C + \beta_4 WeeksOut + \varepsilon.$$

(4) $$\%\ E = \beta_0 + \beta_1 Forecast\ A + \beta_2 Forecast\ B + \beta_3 Forecast\ C + \beta_4 WeeksOut + \varepsilon.$$

Expectations were for the closer to the sale date the price is given, the more accurate the forecasted price would be.

The expected coefficient signs were the same for both equation (3) and (4).). In the experience of the national accounts managers which accounted for over 150 years of combined experience, Forecast A was expected to be negative as it was typically lower

than the USDA market. Forecast B and C were expected to be positive as they were typically above the USDA market. Weeks out variable had no expected sign as forecast error typically increases further out front but the effects were unknown positively or negatively.

CHAPTER V RESULTS

5.1 Raw Data Results

The following tables illustrated the results for each commodity and the number of weeks out front for given advertised quote. Table 5.1 presents summary statistics (mean, standard deviation, minimum, maximum, sample size, and root means squared error) for each rib forecast two weeks out evaluated.

To further explain Table 5.1 data calculations and results, row one indicated the USDA at forecast to Sale. The mean was the average of the fourteen two weeks out front quotes determined by subtracting the FOB sale price from the USDA market price at the time of forecast. The standard deviation of these means was then calculated for these mean values of each sample

The sample size of 14 in Table 5.1 indicated that for the time period studied, fourteen advertised prices two weeks out front were given to Hormel Foods customers.

Table 5.1: Ribs: Two weeks out front Forecast Errors for specific Forecasts

Forecast n=14	Mean	St. Dev	Minimum	Maximum	RMSE
USDA at forecast to Sale	(13.43)	6.81	(27.16)	(2.15)	14.95
Forecast A to Sale	(17.87)	4.89	(27.16)	(8.95)	18.48
Forecast B to Sale	(8.65)	11.66	(25.16)	7.05	14.18
Forecast C to Sale	(10.44)	12.26	(32.60)	8.05	15.77
Average of Forecasts A and USDA to Sale	(15.65)	5.34	(27.16)	(7.05)	16.47
Average of Forecasts B and USDA to Sale	(11.04)	8.45	(26.16)	2.45	13.72
Average of Forecasts C and USDA to Sale	(11.93)	8.49	(25.66)	2.95	14.47
Average of Forecasts A and B to Sale	(13.26)	7.52	(26.16)	(2.45)	15.11
Average of Forecasts B and C to Sale	(9.54)	11.70	(27.10)	7.55	14.77
Average of Forecasts A and C to Sale	(14.15)	8.03	(28.10)	(1.95)	16.13
Average Forecasts A, B, and USDA to Sale	(13.32)	6.83	(26.50)	(2.35)	14.85
Average Forecasts B, C, and USDA to Sale	(10.84)	9.36	(25.50)	4.32	14.10
Average Forecasts A, C, and USDA to Sale	(13.91)	6.99	(26.16)	(2.02)	15.46
Average Forecasts A, B, and C to Sale	(12.32)	8.95	(119.00)	1.05	15.04
Average Forecasts A, B, C, and USDA to Sale	(12.60)	7.93	(25.91)	0.25	14.73

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.2 presents summary statistics for each rib forecast three weeks out evaluated.

Table 5.2: Ribs: Three weeks out front Forecast Errors for specific Forecasts

Forecast n=10	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	(8.76)	8.90	(23.80)	5.93	12.17
Forecast A to Sale	(14.56)	11.11	(35.20)	(1.67)	18.22
Forecast B to Sale	(11.06)	6.62	(20.20)	(1.65)	12.71
Forecast C to Sale	(9.66)	5.44	(15.20)	(0.67)	10.95
Average of Forecasts A and USDA to Sale	(11.81)	9.73	(29.50)	2.13	14.99
Average of Forecasts B and USDA to Sale	(9.91)	6.50	(22.00)	(0.37)	11.67
Average of Forecasts C and USDA to Sale	(9.21)	6.77	(19.50)	2.63	11.22
Average of Forecasts A and B to Sale	(12.96)	7.93	(27.70)	(3.15)	14.99
Average of Forecasts B and C to Sale	(10.36)	5.27	(17.70)	(1.65)	11.50
Average of Forecasts A and C to Sale	(12.26)	7.99	(25.20)	(1.17)	14.41
Average Forecasts A, B, and USDA to Sale	(11.56)	7.84	(16.40)	(0.81)	13.74
Average Forecasts B, C, and USDA to Sale	(9.82)	5.88	(19.73)	(0.47)	11.30
Average Forecasts A, C, and USDA to Sale	(11.09)	8.06	(24.73)	1.19	13.47
Average Forecasts A, B, and C to Sale	(11.86)	6.85	(23.53)	(2.65)	13.52
Average Forecasts A, B, C, and USDA to Sale	(11.08)	7.06	(23.60)	(0.77)	12.95

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.3 presents summary statistics for each rib forecast four weeks out evaluated.

Table 5.3: Ribs: Four weeks out front Forecast Errors for specific Forecasts

Forecast n=13	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	(2.27)	(7.50)	(16.30)	12.15	7.55
Forecast A to Sale	(5.72)	6.95	(18.49)	5.93	8.79
Forecast B to Sale	3.35	8.19	(9.70)	15.30	8.56
Forecast C to Sale	(2.26)	7.44	(20.49)	9.04	7.50
Average of Forecasts A and USDA to Sale	(3.99)	4.50	(9.00)	4.13	5.89
Average of Forecasts B and USDA to Sale	0.54	6.36	(13.00)	7.95	6.13
Average of Forecasts C and USDA to Sale	(2.26)	4.90	(10.50)	4.94	5.23
Average of Forecasts A and B to Sale	(1.18)	4.91	(11.99)	6.93	4.86
Average of Forecasts B and C to Sale	0.55	7.07	(12.99)	11.04	6.82
Average of Forecasts A and C to Sale	(3.99)	5.96	(19.49)	2.93	6.98
Average Forecasts A, B, and USDA to Sale	(1.54)	4.31	(9.23)	5.40	4.42
Average Forecasts B, C, and USDA to Sale	(0.39)	5.57	(10.23)	7.64	5.36
Average Forecasts A, C, and USDA to Sale	(3.42)	4.21	(12.56)	2.73	5.30
Average Forecasts A, B, and C to Sale	(1.54)	5.46	(14.82)	4.60	5.46
Average Forecasts A, B, C, and USDA to Sale	(1.72)	4.50	(10.79)	4.03	4.65

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

In viewing the rib commodity as a whole, the preferred forecast for each time frame using RMSE was different and therefore the current forecasting tools would need to be examined further. The preferred forecast, as determined by RMSE, for ribs two weeks out was the average of Forecast B and the USDA at forecast to sale. For three weeks out Forecast C to

sale was the preferred forecast, as determined by RMSE, for ribs. The average of forecast A, B, and USDA at forecast to sale was the preferred forecast, as determined by RMSE, for ribs four weeks out.

The RMSE results were as expected for two and four weeks out front as no one individual forecast had the lowest RMSE value which was consistent with the expectation that combination forecasts were more accurate. In viewing the two weeks out forecast RMSE values, one forecast company along with the USDA was the most accurate forecast. The four weeks out forecast used two forecast companies and the USDA as the preferred forecast. The RMSE results were not as expected for three weeks out front as the preferred forecast was only one company's forecast versus the expectation of the combinations of forecasts being more accurate when using RMSE values.

This was critical to Hormel Foods as each forecast had a cost associated with it. If certain forecasts were not utilized for each week, it may be cost effective to eliminate one or more of the costs. The rib commodity utilized all three forecast companies so the retention of all three proves valuable.

The one challenge to the rib commodity was the frozen rib program at Hormel Foods. The majority (90%) of retail ribs were booked by the program customers in November or December of each year for the following summer to capture the lowest cost of the USDA market and put down product as frozen inventory that will be thawed at the store level and sold to consumers the following summer. Therefore the usage of forecast companies in the rib commodity was not as valuable as in boneless loins, bone in loins and butts.

Table 5.4 presents summary statistics for each butt forecast two weeks out evaluated.

Table 5.4: Steak Ready Butts: Two weeks out front Forecast Errors for specific Forecasts

Forecast n=20	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	2.99	5.27	(6.15)	13.16	5.94
Forecast A to Sale	0.51	9.38	(13.75)	34.96	9.16
Forecast B to Sale	3.71	9.79	(8.66)	30.96	10.24
Forecast C to Sale	6.66	9.29	(2.75)	37.96	11.24
Average of Forecasts A and USDA to Sale	1.75	6.59	(6.95)	24.06	6.66
Average of Forecasts B and USDA to Sale	3.35	6.01	(3.86)	22.06	6.75
Average of Forecasts C and USDA to Sale	4.82	6.44	(1.43)	25.56	7.92
Average of Forecasts A and B to Sale	2.11	8.79	(10.75)	32.96	8.82
Average of Forecasts B and C to Sale	5.19	9.03	(5.25)	34.46	10.21
Average of Forecasts A and C to Sale	3.59	8.95	(8.25)	36.46	9.43
Average Forecasts A, B, and USDA to Sale	2.40	6.79	(6.48)	26.36	7.04
Average Forecasts B, C, and USDA to Sale	4.45	6.89	(2.82)	27.36	8.05
Average Forecasts A, C, and USDA to Sale	3.39	7.13	(4.82)	28.69	7.73
Average Forecasts A, B, and C to Sale	3.63	8.73	(8.08)	34.63	9.25
Average Forecasts A, B, C, and USDA to Sale	3.47	7.26	(5.55)	29.26	7.88

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.5 presents summary statistics for each butt forecast three weeks out evaluated.

Table 5.5: Steak Ready Butts: Three weeks out front Forecast Errors for specific Forecasts

Forecast n=38	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	3.45	8.68	(13.80)	21.70	9.23
Forecast A to Sale	5.59	10.95	(20.20)	32.80	12.17
Forecast B to Sale	5.51	11.63	(17.75)	32.80	12.76
Forecast C to Sale	10.62	13.48	(9.75)	43.80	17.02
Average of Forecasts A and USDA to Sale	4.52	8.86	(17.00)	23.00	9.84
Average of Forecasts B and USDA to Sale	4.48	8.72	(14.45)	23.00	9.70
Average of Forecasts C and USDA to Sale	7.03	10.12	(10.45)	28.50	12.21
Average of Forecasts A and B to Sale	5.55	10.54	(16.70)	32.80	11.79
Average of Forecasts B and C to Sale	8.06	12.17	(13.75)	38.30	14.46
Average of Forecasts A and C to Sale	8.10	11.64	(13.20)	38.30	14.06
Average Forecasts A, B, and USDA to Sale	4.85	9.02	(15.73)	26.26	10.10
Average Forecasts B, C, and USDA to Sale	6.52	9.94	(12.88)	29.93	11.89
Average Forecasts A, C, and USDA to Sale	6.55	10.07	(13.40)	29.93	11.79
Average Forecasts A, B, and C to Sale	7.24	11.26	(13.20)	36.47	13.26
Average Forecasts A, B, C, and USDA to Sale	6.29	9.94	(13.35)	30.65	11.66

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.6 presents summary statistics for each butt forecast four weeks out evaluated.

Table 5.6: Steak Ready Butts: Four weeks out front Forecast Errors for specific Forecasts

Forecast n=8	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	3.70	10.41	(14.25)	17.95	10.85
Forecast A to Sale	5.48	5.87	(7.78)	10.95	7.76
Forecast B to Sale	10.60	8.27	1.22	28.30	13.13
Forecast C to Sale	17.85	6.51	9.35	27.30	18.86
Average of Forecasts A and USDA to Sale	4.59	7.64	(9.48)	14.45	8.49
Average of Forecasts B and USDA to Sale	7.15	8.58	(4.98)	19.60	10.75
Average of Forecasts C and USDA to Sale	10.78	8.20	(2.45)	20.45	13.23
Average of Forecasts A and B to Sale	8.04	6.53	(3.28)	19.30	10.10
Average of Forecasts B and C to Sale	14.23	6.81	6.72	27.80	15.59
Average of Forecasts A and C to Sale	11.67	5.19	2.22	18.80	12.64
Average Forecasts A, B, and USDA to Sale	6.60	7.28	(5.91)	16.50	9.48
Average Forecasts B, C, and USDA to Sale	10.72	7.60	0.76	22.17	12.86
Average Forecasts A, C, and USDA to Sale	9.01	6.78	(2.24)	17.28	11.02
Average Forecasts A, B, and C to Sale	11.31	5.95	1.89	21.97	12.61
Average Forecasts A, B, C, and USDA to Sale	9.41	6.76	(1.38)	19.20	11.34

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

In viewing the butt commodity as a whole, the preferred forecast for each time frame using RMSE was different but do not include Forecast B or C, and therefore the current forecasting tools would need to be examined further to determine if Forecast B or C could

be eliminated. The preferred forecast, as determined by RMSE, for butts two weeks out was the USDA at forecast to sale. For three weeks out the USDA at forecast to sale was the preferred forecast, as determined by RMSE, for butts. Forecast A to sale was the preferred forecast, as determined by RMSE, for butts four weeks out.

The RMSE results were not as expected for the butt commodity as individual forecasts had the lowest RMSE value which is not consistent with the expectation that combination forecasts are more accurate. In the two weeks out and three weeks out RMSE values, only one USDA price at forecast was the most accurate forecasting tool which is available at no cost to Hormel Foods. The four weeks out forecast used one forecast company for accuracy. Therefore, the costs associated with Forecast B and C was not necessary in accordance with the RMSE results which would save the company incremental bottom line profits.

Table 5.7 presents summary statistics for each bone in loin forecast two weeks out evaluated.

Table 5.7: Bone In Loins: Two weeks out front Forecast Errors for specific Forecasts

Forecast n=18	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	5.07	8.50	(12.74)	19.05	8.83
Forecast A to Sale	4.06	10.01	(14.95)	33.24	10.01
Forecast B to Sale	7.89	4.59	1.05	17.92	9.06
Forecast C to Sale	8.50	5.01	0.05	20.05	9.79
Average of Forecasts A and USDA to Sale	4.56	6.50	(5.65)	20.64	7.79
Average of Forecasts B and USDA to Sale	6.48	4.70	(4.44)	15.80	7.92
Average of Forecasts C and USDA to Sale	6.78	5.09	(2.43)	19.55	8.40
Average of Forecasts A and B to Sale	5.97	5.93	(5.95)	20.74	8.30
Average of Forecasts B and C to Sale	8.19	3.59	1.55	13.92	8.91
Average of Forecasts A and C to Sale	6.28	5.83	(7.45)	20.24	8.45
Average Forecasts A, B, and USDA to Sale	5.67	4.96	(2.75)	16.50	7.44
Average Forecasts B, C, and USDA to Sale	7.15	3.97	(0.26)	13.84	8.13
Average Forecasts A, C, and USDA to Sale	5.87	5.03	(3.75)	16.17	7.64
Average Forecasts A, B, and C to Sale	6.82	4.49	(3.95)	16.24	8.09
Average Forecasts A, B, C, and USDA to Sale	6.38	4.22	(2.05)	14.19	7.59

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.8 presents summary statistics for each bone in loin forecast three weeks out evaluated.

Table 5.8: Bone In Loins: Three weeks out front Forecast Errors for specific Forecasts

Forecast n=33	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	2.40	8.50	(16.74)	18.02	8.71
Forecast A to Sale	(2.20)	9.91	(18.09)	24.39	10.01
Forecast B to Sale	3.13	9.29	(21.45)	15.80	9.67
Forecast C to Sale	4.19	9.08	(13.45)	18.80	9.87
Average of Forecasts A and USDA to Sale	0.10	8.46	(17.34)	17.79	8.33
Average of Forecasts B and USDA to Sale	2.76	7.81	(15.35)	13.81	8.17
Average of Forecasts C and USDA to Sale	3.30	8.17	(11.84)	18.32	8.70
Average of Forecasts A and B to Sale	0.46	8.44	(15.45)	18.89	8.33
Average of Forecasts B and C to Sale	3.66	8.73	(17.45)	16.22	9.34
Average of Forecasts A and C to Sale	1.00	8.72	(12.44)	19.39	8.64
Average Forecasts A, B, and USDA to Sale	1.11	7.88	(15.21)	16.33	7.84
Average Forecasts B, C, and USDA to Sale	3.24	7.99	(14.72)	15.20	8.51
Average Forecasts A, C, and USDA to Sale	1.46	8.20	(13.87)	17.75	8.20
Average Forecasts A, B, and C to Sale	1.71	8.34	(14.78)	17.39	8.39
Average Forecasts A, B, C, and USDA to Sale	1.88	7.96	(13.40)	15.84	8.06

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.9 presents summary statistics for each bone in loin forecast four weeks out evaluated.

Table 5.9: Bone In Loins: Four weeks out front Forecast Errors for specific Forecasts

Forecast n=7	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	11.27	8.25	(0.50)	23.10	13.61
Forecast A to Sale	6.01	7.18	(2.70)	15.30	8.96
Forecast B to Sale	9.29	6.02	2.20	17.30	10.83
Forecast C to Sale	12.01	5.30	5.20	18.30	12.97
Average of Forecasts A and USDA to Sale	8.64	7.22	(1.10)	19.20	10.92
Average of Forecasts B and USDA to Sale	10.28	6.43	2.20	20.20	11.88
Average of Forecasts C and USDA to Sale	11.64	5.69	4.90	19.20	12.77
Average of Forecasts A and B to Sale	7.65	5.82	3.70	16.30	9.36
Average of Forecasts B and C to Sale	10.65	5.37	3.70	17.30	11.75
Average of Forecasts A and C to Sale	9.01	4.97	4.30	16.80	10.12
Average Forecasts A, B, and USDA to Sale	8.86	6.26	2.37	18.57	10.58
Average Forecasts B, C, and USDA to Sale	10.86	5.55	4.57	18.57	12.01
Average Forecasts A, C, and USDA to Sale	9.76	5.67	2.70	17.90	11.08
Average Forecasts A, B, and C to Sale	9.10	5.09	4.20	16.63	10.25
Average Forecasts A, B, C, and USDA to Sale	9.64	5.50	4.35	17.75	10.91

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

In viewing the bone in loin commodity as a whole, the preferred forecast for each time frame using RMSE was different and therefore the current forecasting tools will have to be

examined further. However, Forecast C was not included in any of the preferred forecasts. The preferred forecast, as determined by RMSE, for bone in loins two weeks out was the average of Forecast A, B, and the USDA at forecast to sale. For three weeks out Forecast A, B, and the USDA at forecast to sale was the preferred forecast, as determined by RMSE, for bone in loins. Forecast A to sale was the preferred forecast, as determined by RMSE, for bone in loins four weeks out.

The RMSE results were as expected for two and three weeks out front as no one individual forecast had the lowest RMSE value which was consistent with the expectation that combination forecasts were more accurate. In viewing the two and three weeks out forecast RMSE values, two forecast companies along with the USDA were the most accurate forecast. The RMSE results were not as expected for four weeks out front as the preferred forecast was only one company's forecast versus the expectation of the combinations of forecasts being more accurate when using RMSE values.

Table 5.10 presents summary statistics for each boneless loin forecast two weeks out evaluated.

Table 5.10: Boneless Loins: Two weeks out front Forecast Errors for specific Forecasts

Forecast n=23	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	(0.49)	13.67	(24.15)	29.07	13.38
Forecast A to Sale	(15.44)	12.16	(46.12)	9.75	19.49
Forecast B to Sale	(1.31)	19.61	(29.69)	36.75	19.22
Forecast C to Sale	3.56	19.00	(35.12)	43.75	18.92
Average of Forecasts A and USDA to Sale	(7.96)	9.71	(25.05)	17.55	12.39
Average of Forecasts B and USDA to Sale	(0.90)	15.40	(25.82)	29.05	15.09
Average of Forecasts C and USDA to Sale	1.54	13.51	(21.55)	35.05	13.30
Average of Forecasts A and B to Sale	(8.37)	14.32	(26.45)	23.25	16.31
Average of Forecasts B and C to Sale	1.13	17.69	(28.03)	37.75	17.34
Average of Forecasts A and C to Sale	(5.94)	15.09	(40.62)	26.25	15.91
Average Forecasts A, B, and USDA to Sale	(5.74)	12.59	(25.68)	22.28	13.59
Average Forecasts B, C, and USDA to Sale	0.59	14.90	(23.35)	33.95	14.58
Average Forecasts A, C, and USDA to Sale	(4.12)	12.12	(23.02)	26.28	12.55
Average Forecasts A, B, and C to Sale	(4.39)	15.24	(27.46)	28.08	15.54
Average Forecasts A, B, C, and USDA to Sale	(3.42)	13.41	(24.00)	27.65	13.55

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.11 presents summary statistics for each boneless loin forecast three weeks out evaluated.

Table 5.11: Boneless Loins: Three weeks out front Forecast Errors for specific Forecasts

Forecast n=44	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	0.29	8.81	(19.15)	19.55	10.16
Forecast A to Sale	(7.21)	12.14	(39.95)	8.80	16.83
Forecast B to Sale	11.51	17.08	(18.64)	35.80	19.31
Forecast C to Sale	12.15	15.49	(7.95)	38.80	17.17
Average of Forecasts A and USDA to Sale	(3.46)	6.08	(14.05)	7.50	8.11
Average of Forecasts B and USDA to Sale	5.90	9.35	(9.14)	22.00	9.58
Average of Forecasts C and USDA to Sale	6.22	9.18	(1305.00)	19.50	9.26
Average of Forecasts A and B to Sale	2.15	13.10	(21.95)	22.30	13.88
Average of Forecasts B and C to Sale	11.83	15.41	(12.14)	35.30	17.80
Average of Forecasts A and C to Sale	2.47	12.89	(23.95)	22.30	13.49
Average Forecasts A, B, and USDA to Sale	1.53	8.61	(9.97)	16.27	8.44
Average Forecasts B, C, and USDA to Sale	7.98	10.68	(7.97)	24.27	11.58
Average Forecasts A, C, and USDA to Sale	1.74	8.72	(11.68)	14.80	8.51
Average Forecasts A, B, and C to Sale	5.48	13.42	(17.28)	26.47	14.20
Average Forecasts A, B, C, and USDA to Sale	4.18	10.07	(8.89)	20.05	10.09

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

Table 5.12 presents summary statistics for each boneless loin forecast four weeks out evaluated.

Table 5.12: Boneless Loins: Four weeks out front Forecast Errors for specific Forecasts

Forecast n=13	Mean	St. Dev	Minimum	Maximum	RMSE
USDA to Sale	(7.93)	24.11	(25.50)	10.64	14.25
Forecast A to Sale	(11.05)	17.55	(30.97)	31.30	14.35
Forecast B to Sale	0.57	19.43	(27.97)	24.30	17.33
Forecast C to Sale	6.10	15.10	(16.70)	40.30	13.51
Average of Forecasts A and USDA to Sale	(9.49)	11.83	(26.57)	13.40	13.31
Average of Forecasts B and USDA to Sale	(3.68)	10.57	(24.07)	17.30	9.42
Average of Forecasts C and USDA to Sale	(0.91)	10.59	(21.10)	17.90	11.15
Average of Forecasts A and B to Sale	(5.24)	17.00	(28.47)	26.30	11.59
Average of Forecasts B and C to Sale	3.34	14.99	(14.97)	30.80	15.39
Average of Forecasts A and C to Sale	(2.47)	15.54	(18.70)	35.80	11.16
Average Forecasts A, B, and USDA to Sale	(6.14)	12.36	(26.37)	16.03	9.95
Average Forecasts B, C, and USDA to Sale	(0.42)	11.88	(17.37)	19.03	10.18
Average Forecasts A, C, and USDA to Sale	(4.29)	12.18	(20.97)	22.37	11.12
Average Forecasts A, B, and C to Sale	(1.46)	15.49	(20.30)	30.97	11.12
Average Forecasts A, B, C, and USDA to Sale	(3.08)	12.90	(20.77)	22.10	9.93

Notes: The sample size for each table is indicated in the top cell and described as n=x with n meaning sample size and x indicating the number of samples in the data set with Table 5.1 having 14 data points. The individual forecasts or composite forecasts are indicated in the Forecast column and defined as the particular forecast to the sale price. The column title mean indicates the mean raw error for all errors in the data set. The St. Dev column represents the standard deviation for each forecast company. The final column RMSE indicates root means squared error.

In viewing the boneless loin commodity as a whole, the preferred forecast for each time frame using RMSE was different and therefore the current forecasting tools would have to

be examined further. However, Forecast C was not included in any of the preferred forecasts. The preferred forecast, as determined by RMSE, for boneless loins two weeks out was the average of Forecast A and the USDA at forecast to sale. For three weeks out Forecast A and the USDA at forecast to sale was the preferred forecast, as determined by RMSE, for boneless loins. The average of forecast B and the USDA at forecast to sale was the preferred forecast, as determined by RMSE, for boneless loins four weeks out.

The RMSE results were as expected for all weeks out front as no one individual forecast had the lowest RMSE value which was consistent with the expectation that combination forecasts are more accurate. In viewing the all weeks out forecast RMSE values, one forecast company along with the USDA were the most accurate forecast.

In comparing all commodities, all three companies and the USDA at time of forecast were utilized in one or more preferred forecast. However, company C was only utilized in the rib commodity three weeks out which as previously mentioned may be a mute point in the Hormel Foods forecasting model due to the increase in previously frozen rib bookings success over the past few years and the limited sale of fresh ribs.

Two weeks out front, company A, company B, and the USDA at forecast were used in different combinations for the four commodities preferred forecasting. For three weeks out front, company A, company B, company C (only ribs), and the USDA at forecast were used in different combinations for the four commodities preferred forecast. Finally, four weeks out front, company A, company B, and the USDA at forecast were the preferred forecasts in different combinations for the four commodities. Therefore, based on RMSE alone, the need for forecast company C was questionable.

5.2 Raw Error and Percentage Based Error Model Results

To further build upon the RMSE, several models were developed to interpret statistical significance of forecast accuracy with different variables.

Table 5.13: Estimates for Determinants of Raw and Percentage Errors in Forecasting compared to USDA forecast and boneless loin commodity including forecast companies, weeks out front, and commodities.

Description	Coefficient Estimates	
	Raw Error	Percentage Based Error
Intercept	-9.270 * (1.398 E-06)	-8.122 * (1.350 E-06)
Forecasting Methods (default is USDA)		
Company A	-4.623 * (2.936 E-05)	-3.252 * (0.00076)
Company B	3.140 * (0.0044)	2.601 * (0.0070)
Company C	5.647 * (3.540 E-07)	4.967 * (2.985 E-07)
Other Explanatory Variables (default is boneless loins)		
Weeks Out	2.161 * 0.00018	2.082 * (3.752 E-05)
Ribs	-6.543 * (6.183 E-08)	-5.952 * (2.087 E-08)
Butts	7.951 * (7.196 E-15)	8.605 * (1.138 E-21)
Loins	6.368 * (1.483 E-09)	5.948 * (1.063 E-10)
Adjusted R Squared	0.225	0.218
Number of Observations	963	963

Notes: An asterisk (*) denotes statistical significance at the 0.05 level. The values in parentheses indicate standard errors for equation (1) and (2) listed in Section 4.2.

Equation (1) and (2) presented in section 4.2 were illustrated in the table above with all coefficients being statistically significant. Table 5.13 suggests boneless loin forecast errors (both raw and percentage evaluations) provided by companies B and C are significantly

higher than the USDA's while company A provides forecasts more accurate than the USDA. These results were consistent with the raw data summary statistics presented in tables 5.4-5.12; Company A had forecasted results lower than the USDA market, whereas company C had forecasted results higher than the USDA market with company B being in between company A and C and the closest to the USDA market.

In regards to the other explanatory values, weeks out variable was not expected to have a positive or negative sign as forecast error typically increases further out front but the effects are unknown positively or negatively. However, they were positive in this case as there was an increased opportunity for unforeseen events to occur (ex weather, disease, etc.) and therefore forecast error is likely to increase. Forecasting performance was expected to decline with longer forecasting horizons. This expectation was met as table 5.13 suggests each additional week in forecasting horizon increases forecast error by 2.08%.

The ribs, butts, and loins coefficients utilize boneless loins as a default and therefore were reflection of accuracy relative to boneless loins. We expected the higher valued rib and boneless loin commodities to be easier to forecast than the lower value bone in loins and butts due to higher value changes result in a lower value percentage change. The butt and loin commodities were significantly higher than the default boneless loins which were expected as the changes in value of a lower valued item would equate to a greater error. The rib commodity coefficient was significantly lower than the default boneless loins which were expected as the spare rib commodity demands a lower price than boneless loins per the USDA market close on a regular basis.

Table 5.14: Estimates for Determinants of Raw Errors in Individual Commodity Forecasting

Description	Coefficient Estimates			
	Ribs	Butts	Loins	Boneless Loins
	-24.264 *	-4.925	4.414	-4.751
Intercept	(1.667 E-14)	(0.1127)	(0.1182)	(0.2560)
Forecasting Methods (default is USDA)				
	-4.541 *	0.6977	-3.566 *	-9.817 *
Company A	(0.0247)	(0.6946)	(0.0292)	(8.24 E-05)
	3.160	2.243	1.055	5.383 *
Company B	(0.1163)	(0.2075)	(0.5168)	(0.0294)
	0.891	6.955 *	2.176	9.283 *
Company C	(0.6568)	(.00011)	(0.1819)	(0.0002)
Other Explanatory Values				
	5.397 *	2.932 *	-0.0417	0.581
Weeks Out	(1.150 E-09)	(0.0038)	(0.9637)	(0.6885)
Adjusted R Squared	0.2890	0.0951	0.0582	0.1777
Number of Observations	147	263	231	319

Notes: An asterisk (*) denotes statistical significance at the 0.05 level. The values in parentheses indicate standard errors for equation (3) listed in Section 4.2.

Table 5.14 suggests the following beginning with the ribs column, the intercept, company A, and weeks out coefficients were significant. Company B and C coefficients were not significant at the 0.05 level. In the butt commodity coefficients, company C and weeks out were the only coefficients with significance at a 0.05 level. Only company A had a statistically significant coefficient in the loin commodity. Finally, in the boneless loin commodity companies A, B, and C all yielded statistically significant coefficients. The statistical significance of these variables was decreased when separated into individual commodities due to reduced sample sizes.

The coefficient results yielded expected and unexpected variables. The expectations for the forecasting methods in comparison to the USDA default were as follows; company A negative coefficients, company B either positive or negative coefficients close but to zero, and company C positive coefficients. The only unexpected coefficient sign was butts for company A as the sign was negative. In addition, the expectation of company B for ribs and boneless loins was closer to a value of zero in relation to the USDA. However, the rib coefficient was not significant.

In regards to the weeks out variable, the expectation was neither a positive nor negative value but was positive which indicated a forecast error increase with longer forecasting horizons. The rib, butt, and boneless loin commodities yielded positive coefficients as expected. However, the loin commodity was slightly negative not as expected, but not significant. In reviewing the coefficient on ribs is larger and significant in relation to butts and loins, and therefore suggests that the weeks out coefficient in table 5.13 were largely derived from the rib commodity and slightly by the butt commodity but not by loins. This was critical in the Hormel Foods organization as the rib bookings are subjective to the overall forecasting due to previously mentioned frozen ribs as well as the tonnage associated with the forecasted rib prices being a smaller percent in relation to the butts and loin commodities.

Table 5.15: Estimates for Determinants of Percentage Based Errors in Individual Commodity Forecasting

	Coefficient Estimates			
Description	Ribs	Butts	Loins	Boneless Loins
	-18.601 *	-6.618	4.506	-3.732
Intercept	(6.180 E-12)	(0.0883)	(0.1280)	(0.1839)
Forecasting Methods (default is USDA)				
	-4.138 *	1.293	-3.494 *	-6.268 *
Company A	(0.0184)	(0.5590)	(0.0406)	(0.00017)
	2.364	2.794	0.6159	4.141 *
Company B	(0.1750)	(0.2073)	(0.7169)	(0.0124)
	0.397	8.493 *	1.693	6.699 *
Company C	(0.8194)	(0.00015)	(0.3193)	(5.966 E-05)
Other Explanatory Values				
	4.082 *	3.846 *	0.2109	0.5265
Weeks Out	(6.733 E-08)	(0.0023)	(0.8251)	(0.5513)
Adjusted R Squared	0.223	0.0756	0.0236	0.1755
Number of Observations	147	263	231	319

Notes: An asterisk (*) denotes statistical significance at the 0.05 level. The values in parentheses indicate standard errors for equation (4) listed in Section 4.2.

Table 5.15 beginning with the ribs column suggests the intercept, company A, and weeks out coefficients are significant. Company B and C coefficients were not significant at the 0.05 level. In relation to the butt commodity coefficients, company C and weeks out were the only coefficients with significance at a 0.05 level. Only company A had a statistically significant coefficient in the loin commodity. Finally, in the boneless loin commodity

companies A, B, and C all yielded statistically significant coefficients. The significance of these coefficients was decreased when separated into individual commodities due to reduced sample sizes.

The expectations for the forecasting methods in comparison to the USDA were company A negative coefficients, company B either positive or negative coefficients close to zero, and company C positive coefficients. The only unexpected coefficient sign was butts for company A as the sign was positive. In addition, the expectation of company B for boneless loins was closer to a value of zero in relation to the USDA though it was significant.

In regards to the weeks out variable, the expectation was neither a positive nor negative value but was positive which indicated a forecast error increase with longer forecasting horizons. All commodities yielded positive coefficients as expected with ribs and butts being statistically significant.

5.3 Individual Company Limitations

There were several limiting factors in relation to this study including timing of data, number of data points, only using Hormel sale data, choice of data points, and market variations during the time studied.

The first limiting factor of data timing tied with the market variations during the time studied. A one-year recap of data was gathered from the second half of 2009 and the first half of 2010 fiscal years for Hormel Foods. The second half of 2009 was a very flat market with little to no fluctuation. The market fluctuation that was seen was seasonal related and usually predicted. The first of half of 2010 was more a challenge as the market experienced fluctuations that were not predicted or expected and in turn challenged some of the prediction capabilities. The market continued these atypical fluctuations into the second half of 2010 as well. A more ideal study would follow a five year time series of data to determine a more accurate set of results.

In relating to the five year time series of data to determine more accurate results, the current study of limited data points may have decreased accuracy. If the number of data points was increased over a five year span, the expected results may increase in accuracy.

The next limited variable of only using Hormel sale data limits the factors not only in sample pool, but also in other company overages and internal issues that relate to the costing structure. Unfortunately in a confidential industry and the mandatory pork reporting still in the development stage this information was not available for the competition.

The final limitation was the choice of data points. It is difficult internally to determine which weeks were advertising weeks versus which weeks were normal flow business for each of our customers. To achieve a better set of results, the advertising quotes less freight and marketing accruals could be tracked in a single spreadsheet for ease of obtaining data to review year over year versus utilizing a data base and selecting advertising weeks based on tonnage alone over and above the normal flow business.

CHAPTER VI CONCLUSIONS

This study used models to assess the forecast accuracy of Hormel forecasting tools in relation to the advertised sale price. Using Hormel advertised pricing from fiscal year 2009 half two and fiscal year 2010 half one for ribs, steak ready butts, bone in loins, and boneless loins, we ran regressions for all commodity raw error, all commodity percentage based error, individual commodity raw error, and individual commodity percentage based error to evaluate forecasting accuracy. In addition, root mean square error was used to compare all forecast combinations.

The time period of data collection included relatively flat market conditions of 2009, as well as the sharp peaks and valleys of markets in 2010. Market conditions have continued record prices and have remained high through the remaining of fiscal year 2010 (October 2009-October 2010).

This thesis only observed forecast accuracy from forecast company forecasts to sale prices. It was hypothesized that forecast accuracy decreases with time, company A would be negative, company C would be positive, and company B could be positive but the closest to the USDA default. However, in this study not all signs were expected after running the regression. There were a few issues which may have affected the coefficients of the regression to be unexpected. These include limitation of only Hormel data, only one year of data analyzed, and Hormel valuation of products in relation to USDA commodity pricing.

In the regression, the variables weeks out, company A, company B, and company C, ribs, butts, and loins all had an affect on the error terms. In the overall commodity equations (1) and (2), all coefficients were significant at the 0.05 level when determining raw error or percentage based error. In the individual commodity equations (3) and (4), the statistical significance was lacking due to the decreased number of observations.

The Adjusted R-squared did not indicate that the variables were a very good fit for the regression equations. The Adjusted R-squared values of 0.0236 to 0.2890 indicates that only 2.36-28.90% of the variability in forecast errors was explained by the independent

variables which was expected as the independent variables were prices versus the dependent variable was an error term.

6.1 Implications for Hormel Foods

The implications from the research for Hormel Foods included a variety of areas. These implications included the ideal forecasting methods to limit risk by utilizing the proper combination of forecast for each specific commodity and weeks out, potential elimination of one or more of the forecasting companies, and the ability to be considered an expert by the customer at forecasting by providing accurate forecasts.

The ideal forecasting methods to limit risk using RMSE results was presented in table 5.1-5.12. The ideal forecasts forecasting methods for each commodity and week out will be utilized within the company when forecasting advertised quotes with our customers. These ideal forecast methods for each commodity allow for further evaluation of the forecasting companies utilized within Hormel Foods. The cost of forecasting companies is a major bottom line expense within the fresh pork team. The preferred forecasts for the different commodities and weeks out front only used company C for one of the preferred forecasts. Therefore, Hormel must seriously consider eliminating the cost associated with company C. Even more important to the Hormel Foods organization outside of limiting risks and costs is customer confidence. The ability to accurately forecast advertising quotes relative to the predicted market conditions allows our customers the confidence in our business and the reassurance of a partnership.

6.2 Future Research

For future research on forecasting accuracy, I would suggest including other reported data in relation to forecasts and forecast company combinations. Other forecasts may be available and increase accuracy for other companies. Other variables to possibly include could include export sales, sold up position, weather (winter storms or hot summer days) and costs of each forecast company in relation to margin.

In addition, the future research may include the correct direction of the forecasts verses the average error. This may prove to be more important to the company to avoid forecasting errors in missed USDA markets.

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