# TARGETING PRIME:

# EXAMINING THE ECONOMIC ELEMENTS

# BEHIND WAGYU-INFLUENCED CATTLE

By

GRACE A. BAXTER

Bachelor of Science in Animal Science

Texas Tech University

Lubbock, Texas

2021

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 2023

TARGETING PRIME:

EXAMINING THE ECONOMIC ELEMENTS

BEHIND WAGYU-INFLUENCED CATTLE

Thesis Approved:

Dr. Kellie Curry Raper

Thesis Adviser

Dr. Derrell Peel

Dr. Hannah E. Shear

## ACKNOWLEDGEMENTS

Pursuing my Master's Degree at Oklahoma State University has been one of the most rewarding endeavors I have accomplished thus far. I want to extend a huge thank you to my thesis advisor, Dr. Kellie Curry Raper, for always believing in me and motivating me to compete, write, or present research to the best of my capabilities. Her guidance and excitement have helped make this a phenomenal experience. I would also like to thank Dr. Derrell Peel and Dr. Hannah E. Shear for their enthusiasm to participate as my committee members. My 3 Minute Thesis speech would not have been as successful as it was without the help of Dr. Shear. I have greatly enjoyed opportunities to travel across Oklahoma with Dr. Peel and learn so much from him on agricultural tours. The impact all three have had on my time at this university is profound.

Thank you to the specialty ranch and feedlot for sharing data with us to utilize in our case study. Without their support or involvement, this research would not have been possible. It has been wonderful to interact with their team and share our results. Hopefully these results will have an impact on their operation and create a better understanding of Wagyu-influenced cattle's place in the beef industry.

I am very thankful for various individuals in the Department of Agricultural Economics. Dr. Cheryl DeVuyst is one of my greatest advisors; I am lucky to have her encouragement as a student, woman of faith, and cattlewoman. Dr. Eric DeVuyst has tremendously helped me with data analysis for Chapter 3 of this thesis; I am glad to also have him as a role model for my religious faith. Dr. Rodney Holcomb is my favorite mentor for professional and personal life advice. I will always cherish the time I have spent with these faculty members.

I greatly appreciate those in my cohort as we have supported each other through obtaining this degree and I consider as good friends. Thank you to my best friend, Charlotte Streat, for being a source of constant encouragement and your relentless friendship. I also would like to thank my other friends from all walks of life who have been beside me along the way.

Last but certainly not least, I could not have accomplished graduating without the help of my family, specifically Jeff, Dana, and Faith Baxter. Jeff, thank you for always pushing me to succeed in whatever I set my mind to and for always making me laugh in the face of challenges. Dana, thank you for your endless love, caring heart, and being there for all of life's good or bad moments. Faith, thank you for being my lifelong best friend, favorite adventurer, and voice of reason. All of your love has helped me stay strong through life's hardest battles and continued to uplift me during life's greatest highs.

Name: GRACE A. BAXTER

Date of Degree: MAY, 2023

Title of Study: TARGETING PRIME: EXAMINING THE ECONOMIC ELEMENTS BEHIND WAGYU-INFLUENCED CATTLE

Major Field: AGRICULTURAL ECONOMICS

Abstract: Wagyu beef is an increasingly popular product among today's U.S. beef consumers because of its taste and tenderness resulting from high amounts of marbling and unique healthy fat composition. Low average daily gains and extended production cycles of Wagyu cattle have encouraged producers to crossbreed Wagyu with Angus, a popular U.S. breed of British descent, to attain these desired carcass and flavor characteristics more efficiently. Progeny from this crossbreeding effort are called Wangus. Most research conducted over Wagyu cattle has only examined physical differences between Wagyu and conventional beef breeds, but with no economic analysis. Objective 1 analyzes price composition for fed Angus cattle and for Wangus cattle of varying Wagyu genetic influence, including whether price premiums are associated solely with carcass characteristics or if a component of price is driven by perceived quality attributable to the Wagyu name. Research uses a hedonic model analysis of Wangus fed cattle price components. Objective 2 compares feedlot profitability across sex, feedlot start weight, and various genetic percentages in Wangus cattle with an ANOVA test. The Analysis of Variance (ANOVA) procedure is implemented with Tukey's method to determine pairwise differences among subgroups. Results indicate premiums exist not only for certain carcass attributes but also for association with Wagyu beef. While 25% and 12.5% Wagyu cattle may not have American Wagyu marketing advantages, producers may receive premiums from these cattle based on buyers' perceptions of Wagyu and an increased rate of cattle achieving USDA Prime quality grades. Significant premiums exist for reaching USDA Prime quality grades. Discounts are significant for USDA yield grades above 3. The analysis found differences exist in feedlot profitability among Angus and Wangus genetics. Wangus cattle with 25% and 12.5% Wagyu on average have higher net returns compared to Angus. On average, 50% Wagyu had the lowest net returns. Unexpectedly, there was no statistical difference in average profitability between steers and heifers. Differences exist in profitability among feedlot start weight groups with lighter weight cattle having higher mean net returns than heavier cattle. Results concluded price premiums could be achieved while minimizing losses of additional costs typically associated with Wagyu.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

# CHAPTER I

# WHY WAGYU?

## Introduction

Wagyu beef is an increasingly popular product among today's U.S. beef consumers because of its taste and tenderness resulting from high amounts of marbling and unique healthy fat composition. Wagyu genetics contribute to a higher amount of oleic acid, a healthy monounsaturated fat, in beef (Smith, 2018). Marketing opportunities for Wagyu beef continue to grow with increased options in online shopping, product differentiation, and grocery delivery capacities facilitating market access to Wagyu beef products for more consumers (Ghelani and Hua, 2022). While increasing in size, Wagyu is still a very small market and reliable statistics are difficult to find. HNY Research (2021), an independent market research and consulting company, reported an expected compound annual growth rate of 3.7% in the global Wagyu retail beef market through 2027. Not surprisingly, 2019 data indicate North America had a 24% market share of global Wagyu beef consumption (Technavio, 2021). U.S. median household income per capita in 2021 was $69,021 and is ranked as one of the top 10 countries in this category (U.S. Census Bureau, 2023). Dubois et al. (2001) found consumers with higher incomes can justify purchasing expensive luxury goods due to the quality and utility associated with those goods. Beef is defined as a luxury good based on its income elasticity, meaning as income increases, budget share for beef products also increases (Gallet, 2010). Godfray et al. (2018) share that increases in global per capita consumption of meat is driven by increasing individual disposable incomes and population growth. It is difficult to find current statistics for Wagyu beef consumption in the U.S. However, the USDA (2023) reported U.S. beef consumption per capita at 59.1 pounds for beef products (retail weight) in 2022. U.S. Wagyu beef supply consists of both domestic and imported product, with an increase in the number of Wagyu-influenced cattle contributing to domestic supply.

**Wagyu in the U.S.**

Four Japanese Wagyu bloodlines were originally imported into the U.S. in 1975 (American Wagyu Association, 2023a). About 200 head of Wagyu breeding stock were imported from 1975 to 1997. Imports halted in 1997 when the Japanese government enacted an export ban, declaring the cattle a national living treasure (American Wagyu Association, 2023a). However, the breed has continued to grow, with purebred registrations for 2021-2022 exceeding 11,000 head (American Wagyu Association, 2022). According to Steve Bennett, past Executive Officer in the Australian Wagyu Association and owner of Wagyu International (2019), approximately 40,000 head of Wagyu and Wagyu crossbred cattle were on feed in the U.S. in 2019.

Past research found Wagyu cattle exhibit slower growth rates requiring significantly more days on feed. Conventional U.S. cattle on a grain-finishing diet are harvested between 14 to 22 months of age while purebred Wagyu cattle are harvested between 29 to 32 months of age (Broocks et al., 2017; Mizoguchi et al., 2005). Lunt et al. (1993) concluded Angus steers gained approximately 0.45 pounds more per head per day than American Wagyu. Radunz et al. (2009) found Wagyu-sired cattle from Angus cows were on feed an average of 77 days longer than

Angus-sired cattle. This extended production cycle increases production cost per pound for Wagyu cattle relative to other breeds.

Wagyu were bred with Angus, a popular U.S. breed of British descent, in an effort to achieve more efficient feed conversion. Progeny from this crossbreeding effort are called Wangus cattle. Crossbred offspring tend to exhibit hybrid vigor regarding increased performance, feedlot health, heavier carcass weights, and improved yield grades (Barker, 1995). Wangus cattle combine the most advantageous traits from Angus cattle; including high calving ease, high growth rates, increased marbling, and a large genetic population, with Wagyu's low birth weights, exceptional marbling, and superior taste and tenderness (American Angus Association, 2013; American Wagyu Association, 2023b).

**Supply Chain Linkages**

Given the unique nature of Wangus production, producers may benefit from direct relationships with feedyards, processors, and buyers. These relationships can reduce costs, give flexibility to problem resolution, and improve value signals (Schroeder, Coffey, and Tonsor, 2021). A case study approach can further enhance understanding linkage importance within different segments of the Wagyu and Wagyu-influenced beef supply chain. Data was sourced from a Midwestern specialty cattle ranch focused on Wangus cattle and operating in seedstock, cow-calf, and feedlot stages of the beef supply chain (Figure 1). The specialty ranch's supply chain relationships were examined through interviews with their customers, including those who purchase Wangus genetics and market calves back to the ranch-owned feedlot as well as those who purchase fed Wangus cattle at harvest. Email and phone surveys were conducted with both customer groups. Surveys evaluated fed cattle buyers' and Wangus bull customers' motivations and marketing of Wagyu-influenced cattle within these supply chain relationships with the specialty ranch and feedlot. Half (16) of the 32 Wangus bull customers and two-thirds (4) of 6 fed cattle buyers responded. Surveys are included in the appendix (OSU IRB-22-357).

All bull customers were cow-calf producers. The ranch initially created a calf buy-back agreement to purchase bull customers' Wangus cattle for their feedlot. This program ended in 2019. Half participated in the calf buy-back program, securing a market for their Wangus calves. Annual calf crops ranged from 30 to 850 head with varied percentages of Wagyu-influenced calves. Two-thirds reported no additional production costs associated with Wagyu genetics (excluding bull purchases), though customers primarily sold Wangus calves and additional costs are more likely during the later feeding stage. Forty percent reported market premiums for those calves, averaging 27.5% above other calves they sold. After the buy-back program ended, one-third of producers fed calves to harvest weight to market Wangus freezer beef directly to consumers while two-thirds sold calves at local auctions, reporting little to no marketing – an indication of the buy-back program's importance for those producers (Figure 2). Survey questions asked about motivations for implementing Wagyu genetics. Responses are represented in a word cloud. Word clouds are a qualitative method of illustrating text data where larger font sizes represent a higher frequency of keywords (Jin, 2017). Bull customers most commonly cited motivations were marbling and quality (Figure 3).

The feedlot's two primary fed cattle customers individually comprise 75% and 23% of sales, leaving 2% purchased by smaller buyers. Customers procured 10 to 50% of their annual fed cattle purchases from the feedlot. Responses indicate supply chains do differ between larger and smaller scale customers (Figure 4). Larger buyers procure fed Wangus cattle weekly or biweekly, process cattle in their own packing plant, and distribute branded beef products to retail entities. Smaller fed cattle buyers only procure Wangus cattle annually or biannually, secure custom slaughter, and distribute the beef to butcher shops, consumers, or small-scale retailers. Both report paying 15% premiums to the feedlot over their other cattle procurements and selling

Wangus beef for 50% premiums over other beef products they sell, on average. Feedlot customers view Wangus beef as part of a portfolio mainly composed of Angus beef, local and natural claims, prime quality grades or a combination of attributes. Fed cattle buyers indicated their most common motivations for purchasing Wangus cattle were to attain prime USDA quality grades (Figure 5). Similar motivations exist for both customer groups to purchase Wagyu-influenced cattle for their unique carcass traits. Both customer groups are utilizing Wangus to also increase the proportion of prime grading cattle rather than for marketing the Wagyu name.

**Objectives**

Most research conducted over Wagyu cattle has only examined physical differences between Wagyu and conventional beef breeds, but with no economic analysis (e.g., Lunt et al., 1993; Mir et al., 1999; Radunz et al., 2009; McGee et al., 2013; Park et al., 2018). Research will inform cattle producers about economic considerations associated with producing Wagyu-influenced cattle. Understanding price premiums and profitability associated with Wangus cattle can provide cattle producers knowledge to make informed decisions regarding production of Wagyu-influenced cattle.

Objective 1 analyzes price composition for fed Angus cattle and for Wangus cattle of varying Wagyu genetic influence, including whether price premiums are associated solely with carcass cut-out characteristics or if a component of price is driven by perceived added quality attributable to the Wagyu name. Research uses a hedonic model analysis of Wangus price components. Objective 2 compares feedlot profitability across sex, feedlot start weight, and various genetic percentages in Wangus cattle. Analysis of Variance (ANOVA) procedure is a multiple comparison analysis test implemented with Tukey’s method to determine pairwise differences among subgroups (McHugh, 2011).

## Figures

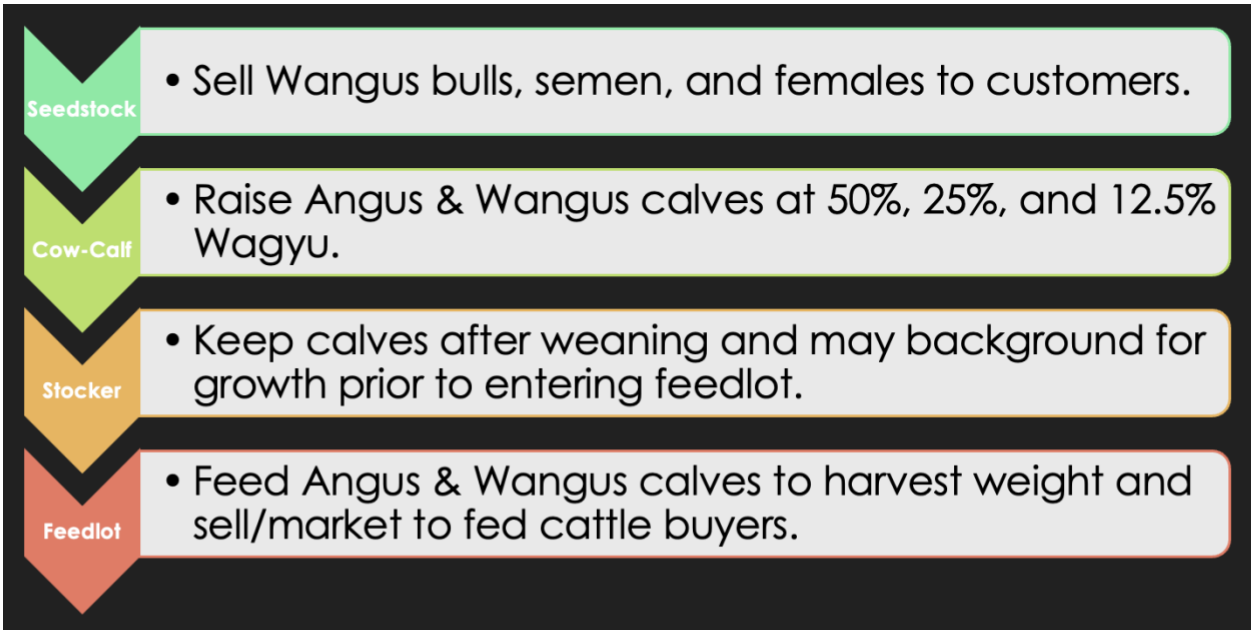


Figure 1.1. Specialty Cattle Ranch Supply Chain

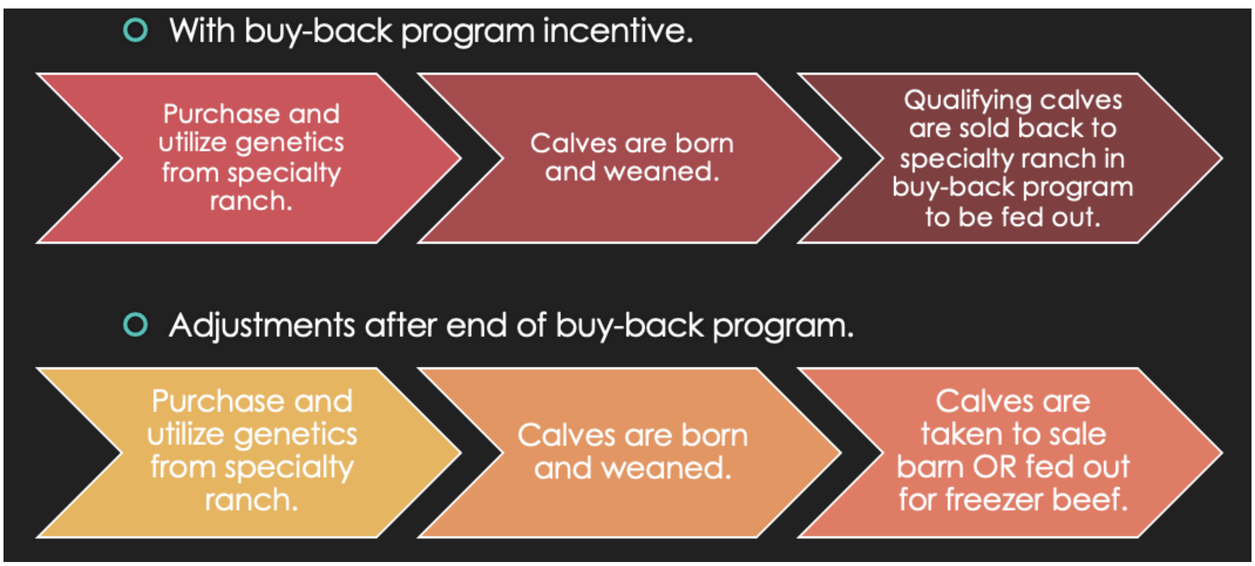


Figure 1.2. Supply Chains Reported by Specialty Ranch's Wangus Bull Customers


Figure 1.3. Wangus Bull Customer Motivations for Purchasing Wagyu-influenced Genetics (n = 16) Note: Larger fonts indicate higher response frequency from survey participants.

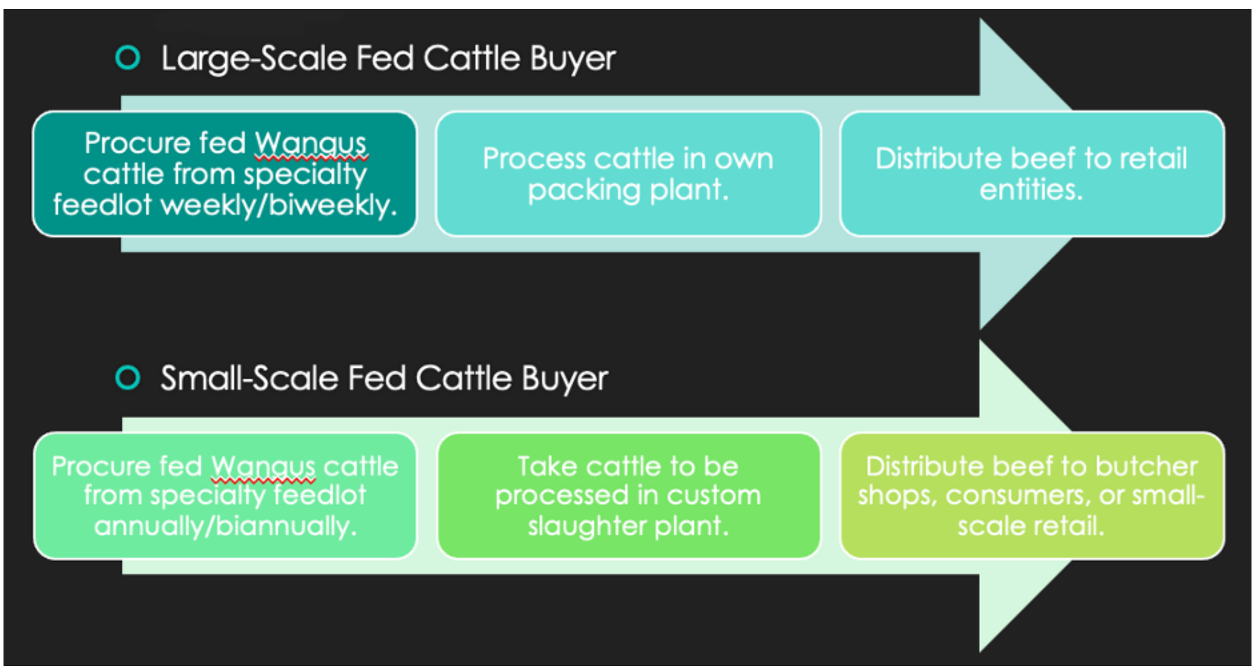


Figure 1.4. Supply Chains Reported by Specialty Ranch's Fed Cattle Buyers


Figure 1.5. Fed Cattle Buyer Motivations for Purchasing Wagyu-influenced Cattle (n = 4) Note: Larger fonts indicate higher response frequency from survey participants.

# REFERENCES

American Angus Association. 2013. “Angus Advantages.” *American Angus Association.* Found at: https://www.angus.org/Pub/advan.pdf, pp. 4-10.

American Wagyu Association. 2022. “2021-2022 Wagyu Registrations.” personal communication. Shared with consent to use numbers in research.

American Wagyu Association. 2023a. “Wagyu Breed History in USA.” *American Wagyu Association*. Found at: https://wagyu.org/for-consumers/what-is-wagyu-beef.

American Wagyu Association. 2023b. “Wagyu Today?” *American Wagyu Association*. Found at: https://wagyu.org/for-consumers/what-is-wagyu-beef.

Barker, B.P., W.L. Mies, J.W. Turner, D.K. Lunt, and S.B. Smith. 1995. “Influence of Production System on Carcass Characteristics of F1 Wagyu x Angus Steers and Heifers.” *Journal of Meat Science* 41(1): 1-5.

Bennett, S. 2019. "The Wagyu Herd in USA." *Wagyu International*. Found at: http://www.wagyuinternational.com/global_USA.php.

Broocks, A., E. Andreini, M. Rolf, and S. Place. 2017. "Carbon Footprint Comparison Between Grass- and Grain-finished Beef." *Oklahoma Cooperative Extension Service* ANSI-3292.

Dubois, B., G. Laurent, and S. Czellar. (2001). "Consumer Rapport to Luxury: Analyzing Complex and Ambivalent Attitudes." *Psychology & Marketing* 18(11): 1081-1106.

Gallet, C.A. 2010. "The Income Elasticity of Meat: A Meta-analysis." *The Australian Journal of Agricultural and Resource Economics* 54(4): 477-490.

Ghelani, D. and T.K. Hua. 2022. "A Perspective Review on Online Food Shop Management System and Impacts on Business." *Advances in Wireless Communications and Networks* 8(1): 7-14.

Godfray, H.C.J, P. Aveyard, T. Garnett, J.W. Hall, T.J. Key, J. Lorimer, R.T. Pierrehumbert, P. Scarborough, M. Springmann, and S.A. Jebb. 2018. "Meat Consumption, Health, and the Environment." *Science* 361(6399): 1-8.

HNY Research. 2022. "2022-2027 Global and Regional Wagyu Beef Industry Status and Prospects Professional Market Research Report." *HNY-RESEARCH*-695-1641275796831.

Jin, Y. 2017. "Development of Word Cloud Generator Software Based on Python." *Procedia Engineering* 174: 788-792.

Lunt, D.K., R.R. Riley, and S.B. Smith. 1993. "Growth and Carcass Characteristics of Angus and American Wagyu Steers." *Meat Science* 34(3): 327–334.

McHugh, M.L. 2011. "Multiple Comparison Analysis Testing in ANOVA." *Biochemia Medica* 21(3): 203-209.

Radunz, A.E., S.C. Loerch, G.D. Lowe, F.L. Fluharty, and H.N. Zerby. 2009. "Effect of Wagyu-versus Angus-sired Calves on Feedlot Performance, Carcass Characteristics, and Tenderness." *Journal of Animal Science* 87(9): 2971-2976.

Schroeder, T.C., B.K. Coffey, and G.T. Tonser. 2021. "Enhancing Supply Chain Coordination through Marketing Agreements: Incentives, Impacts, and Implications." In B.L. Fischer, J.L. Outlaw, and D.P. Anderson, eds. *The U.S. Beef Supply Chain: Issues and Challenges, Proceedings of a Workshop on Cattle Markets.* College Station, TX: Texas A&M University, Agricultural and Food Policy Center, pp. 81-101.

Technavio. 2021. "Wagyu Beef Market by Product and Geography – Forecast and Analysis 2021-2025." IRTNTR71728. Found at: https://www.technavio.com/report/wagyu-beef-market-industry-analysis.

U.S. Census Bureau. 2023. "Quick Facts." Available at: https://www.census.gov/quickfacts/fact/table/US/INC110221.

USDA, World Agricultural Outlook Board. 2023. "World Agricultural Supply and Demand

Estimates." *USDA Economic Research Service.* Available at: https://www.ers.usda.gov/data-products/livestock-and-meat-domestic-data/livestock-and-meat-domestic-data/#All%20Meat%20Statistics.

# CHAPTER II

# INFLUENCE OF WAGYU BEEF GENETICS ON FED CATTLE PRICE

## Introduction

Increasing consumer demand for Wagyu beef, coupled with higher prices relative to conventional beef, has spurred some cattle producers to differentiate and supply this growing market seeking to capture potential profits. Consumers enjoy the unique flavor and tenderness associated with Wagyu and are willing to pay premiums for these traits that result in a high-quality eating experience. At Raider Red Meats, Texas Tech University's in-person and online meat store, Wagyu certified ribeye steaks sell at $5.21 per ounce while USDA Prime ribeye steaks sell at $2.61 per ounce (Raider Red Meats, 2023). However, low average daily gains and extended production cycles of Wagyu cattle have encouraged producers to crossbreed Wagyu with Angus cattle. These progeny, known as Wangus, benefit from heterosis that occurs when combining Wagyu's unique carcass traits with Angus' production efficiency.

For meat labelling and marketing, the USDA Agricultural Marketing Service (AMS) requires cattle be traceable to at least one registered fullblood or purebred (93.75%) Wagyu parent to qualify for Wagyu-influenced certified beef programs, such as American Wagyu (Nelson, 2021). Even when cattle do not qualify for Wagyu labelling, producers may capture added value from Wagyu genetics. Wagyu genetics can increase the percentage of cattle grading prime at harvest, resulting in premiums for this coveted carcass trait. Radunz et al. (2009) found Wagyu-sired fed cattle graded prime at a rate of 65% compared to 21% for Angus-sired cattle, resulting in a higher value carcass and more highly marbled beef cuts. Anecdotal evidence suggests Wangus cattle may command a price premium relative to cattle without Wagyu genetics, based on Wagyu's reputation for unique flavor and tenderness, even when those cattle do not qualify to be marketed as American Wagyu.

**Objectives**

While influence of carcass traits on price is well known, it may not fully explain price differences. A component of producer price may be driven by perceived added quality attributable to the Wagyu name. This research analyzes price composition for fed Angus cattle and for Wangus cattle of varying Wagyu genetic influence. A specific objective is to measure price components associated with carcass characteristics and degrees of Wagyu influence. If price premiums are significant for Wagyu genetics, beyond the impact of specific carcass traits, then additional value of Wangus carcasses may be attributed to market value added by marketing and public perception.

**Literature Review**

Research to date on both full-blood or American Wagyu cattle and beef has not studied economic viability but rather differences in production efficiencies and retail product characteristics. Early studies found Wagyu influenced cattle had lower red meat yield and feedlot performance compared to conventional crossbred beef cattle (Lunt et al., 1993; Mir, 1999). Radunz et al. (2009) noted Wagyu-sired cattle from Angus cows had a decreased daily feed intake relative to full-blood Angus, helping explain why this breed requires more days on feed. While it is evident Wagyu cattle would have more desirable USDA quality grades than domestic beef breeds due to their high marbling genetics, undesirable USDA yield grades can result in carcass discounts (Lunt et al., 1993). McGee et al. (2013) stated research with Wagyu cattle to produce more feed-efficient animals with high intramuscular fat and improved growth rates will help maximize profitability. Radunz et al. (2009) and McGee et al.'s (2013) research on production cycle differences of Wagyu cattle from conventional breeds raises questions about cost versus value.

Scientists have investigated what defines Wagyu as a specialty breed versus conventional breeds. Iida et al. (2014) concluded Wagyu beef samples with an intramuscular fat content of 23.8% to 48.6% had increased tenderness and juiciness relative to conventional beef. In contrast, Park et al. (2018) reported Angus carcasses typically average 14.7% intramuscular fat. U.S. consumers noted palatability trait differences between samples of fullblood Wagyu and Angus beef (Smith, 2016). These differences are attributed to the higher and distinct fat composition of Wagyu. Wagyu cattle have a higher genetic propensity to produce oleic acid, a molecule correlating with marbling, which helps reduce cardiovascular disease risk (Smith, 2016). Wagyu is treated differently in Japanese markets based on its distinctive eating characteristics. Thompson (2004) documented Japanese beef consumption is evaluated under three categories: imported beef, domestic dairy beef, and Wagyu beef. Mori et al. (1989) also noted previous studies of meat markets in Japan treated Wagyu as a separate category from imported beef or domestic dairy beef.

In agriculture, a majority of the market is composed of commodity products and producers rely on cost saving production methods to make a profit (Hayes and Lence, 2002). Jin et al. (2008) found price premiums existed for brands within the fresh produce sector, but branded produce experienced a smaller market share compared to brands in other household good categories. Hayes and Lence (2002) concluded if agricultural producers could embrace niche products or strive to produce in brand affiliations, there could be opportunities for consumers to pay the extra cost. Wahl et al. (1995) specifically examined the contribution of quality characteristics to prices of Japanese Wagyu beef. A hedonic price model was implemented using a semi-log function to understand implicit values Japanese consumers placed on the following characteristics: carcass weight, ribeye area, ribeye thickness, backfat thickness, intermuscular fat thickness, yield grade, sire information, marbling score, specific components of quality, and quality grade. Wahl et al. (1995) concluded ribeye area and marbling score had positive effects on beef carcass price while sires, meat firmness, and meat texture also had significant effects. Similar to Wahl et al. (1995), this study utilizes a hedonic model to measure differences in fullblood Angus and percentages of Wagyu heritage instead of fullblood Wagyu.

**Data**

Data were secured from a privately owned feedlot in the Midwest region of the United States. Fed cattle buyers for this feedlot are composed of both small- and large-scale customers featuring portfolios of USDA Prime beef, Angus beef, and locally raised claims. There are a total of 20,750 observations, consisting of 17,152 head of Angus cattle and 3,418 head of Wangus cattle. Harvest dates range from January 2013 through July 2021. Data includes individual carcass characteristics for both Wangus and Angus cattle including USDA quality grade, USDA yield grade, gender, ribeye area in inches squared, hot carcass weight in pounds, live weight in pounds, and sales price in U.S. dollars. For Wangus cattle, the extent of Wagyu genetics is recorded as 50%, 25%, or 12.5%. For clarity of communication, Wagyu genetics are designated as $W_{50}$, $W_{25}$, and $W_{12.5}$. USDA quality grade is assigned to each carcass primarily based on the degree of marbling (Hales et al., 2013). All nine USDA quality grades of marbling distribution from Standard to High Prime are represented in the data. Cutability contributes to USDA yield grade which ranges from one to seven, specifically in this data set (ZoBell et al., 2005). USDA only reports yield grades one through five, but the yield grade calculation in equation (1) technically could estimate yield grades six and seven (ZoBell, 2005).

(1) $$Yield\ Grade = 2.50 + (2.50 * Adjusted\ FT) + (0.20 * Percent\ KPH\ Fat) + (0.0038 * HCW) - (0.32 * REA)$$

In equation (1), $FT$ is Fat Thickness in inches, $KPH$ is Kidney, Pelvic, and Heart, $HCW$ is Hot Carcass Weight in pounds, and $REA$ is Ribeye Area in inches squared. The feedlot keeps more detailed information on higher yield grade animals in order to calculate USDA yield grades above five. Several observations had missing data and were removed. Only one observation was recorded as yield grade seven, so this observation was also dropped. As a result, the number of total usable observations decreased to 17,253 with 15,006 head of Angus cattle and 2,247 head of Wangus cattle. Table 1 provides variable definitions and summary statistics.

**Methods & Procedures**

Since harvest dates range from 2013 to 2021, annual and seasonal effects need to be neutralized. CME Fats Daily Futures price data were acquired from the Livestock Marketing Information Center (LMIC). Sales price per head was divided by live weight to create sales price in dollars per hundredweight in equation (2) below.

(2) $$PCWT = \left(\frac{SP}{LW}\right) * 100$$

Cattle were assigned a CME Fats Daily Futures price corresponding with harvest date or the next available contract date. CME Fats Daily Futures price is subtracted from sales price to obtain basis in dollars per hundredweight as shown in equation (3).

(3) $$Basis = PCWT - FCWT$$

CME Fats Daily Futures price data should neutralize annual effects. However, it is unknown if seasonality effects will also be neutralized with this data, so quarterly dummy variables are included to capture any remaining seasonality. Allocation of quarterly variables were based on the month of each animal's harvest date. Quarter one includes months January through March, quarter two is April through June, quarter three is July through September, and quarter four is October through December. For clarity of communication, harvest date quarters are denoted as $Q_1$, $Q_2$, $Q_3$, and $Q_4$.

Dressing percentage was calculated dividing hot carcass weight by live weight and is stated in percentages to increase ease of interpretation. Ribeye area and dressing percentage are continuous variables while Wagyu percentage, USDA quality grade, yield grade, gender, and harvest date quarters are categorical variables.

One of the most well-known product differentiation models is by Rosen (1974), who proposed the theoretical framework for the hedonic price model. A hedonic price model evaluates how a set of goods are valued based on individual values of utility attributes or characteristics. Rosen noted when goods are treated as fixed bundles of characteristics, observed market price differences would be comparable because of standards for those characteristics. The framework for a hedonic price model is:

$$(4) \qquad z = (z_1, z_2, \dots, z_n)$$

$$(5) \qquad p(z) = p(z_1, z_2, \dots, z_n)$$

where $n$ is number of measured characteristics, $z$ measures the amount of the characteristic contained in each good, and $p(z)$ is a price defined at each combination of $z$ and $n$.

The hedonic price model, implemented here, models price as a function of Wagyu percentages, USDA quality and yield grade, ribeye area, dressing percentage, gender, and harvest date quarters. Angus, steers, USDA Average Choice quality grade, USDA yield grade 3, and $Q_1$ are chosen as reference categories, based on those respective categories having the highest frequency among observations. The hedonic price model is formulated in equation (6) in a linear-

linear format with each variable defined as shown in Table 1 and $\epsilon$ as a disturbance term where $i$ is each individual animal.

(6) $$Basis_i = \beta_1 + \beta_2 W_{50} + \beta_3 W_{25} + \beta_4 W_{12.5} + \beta_5 ST + \beta_6 SE_L + \beta_7 SE_H + \beta_8 CH_L + \beta_9 CH_H + \beta_{10} PR_L + \beta_{11} PR_A + \beta_{12} PR_H + \beta_{13} YG1 + \beta_{14} YG2 + \beta_{15} YG4 + \beta_{16} YG5 + \beta_{17} YG6 + \beta_{18} DP + \beta_{19} REA + \beta_{20} H + \beta_{21} Q_2 + \beta_{22} Q_3 + \beta_{23} Q_4 + \epsilon$$

The estimated hedonic price model assigns a monetary value to each trait and Wagyu percentage variable. While individual parameter estimates are of interest, three key joint hypotheses are also tested using F-tests. Hypothesis 1: Carcass traits do not influence price. The alternative hypothesis is carcass traits do influence price.

(7) $$H_0: \beta_5 = \cdots = \beta_{20} = 0$$

$$H_A: At\ least\ one\ \beta \neq 0$$

However, this test does not fully explain all potential impacts on Wangus cattle prices.

Hypothesis 2: Wagyu percentage level has no influence on price. The alternative hypothesis is Wagyu percentage level does influence price.

(8) $$H_0: \beta_2 = \beta_3 = \beta_4 = 0$$

$$H_A: At\ least\ one\ \beta \neq 0$$

The CME Fats Daily Futures adjustment to price neutralizes any annual price impacts but may not neutralize seasonality. Hypothesis 3: CME Fats Daily Futures price adjustment neutralizes seasonality effects on price. The alternative hypothesis is CME Fats Daily Futures price adjustment does not neutralize seasonality effects on price.

(9) $$H_0: \beta_{21} = \beta_{22} = \beta_{23} = 0$$

$$H_A: At\ least\ one\ \beta \neq 0$$

**Results & Discussion**

Estimated results from the hedonic price model in equation (6) are presented in Table 2. Regression analysis was conducted using proc reg, a simple linear regression, in SAS 9.4. Output includes parameter estimates and p-values. Auto-correlation and heteroskedasticity tests were conducted for model diagnostics. The Breusch-Godfrey test indicates no autocorrelation is present in the model (Durbin-Watson = 0.413, p < 0.0001). Heteroskedasticity tests performed in SAS indicate no significant heteroskedasticity in the hedonic price model ($\chi^2$ = 13362.4, p < 0.0001). Analysis of OLS assumptions conclude the model is structured properly to estimate accurate results.

Hypothesis 1 that $\beta_5 = \cdots = \beta_{20} = 0$ is rejected concluding carcass characteristics as a group do influence price (F = 440.85 and p < 0.0001). Additional price variability is explained by Wagyu influence on Wangus carcass prices. Hypothesis 2 that $\beta_2 = \beta_3 = \beta_4 = 0$ is also rejected concluding Wagyu genetics percentage does influence price (F = 14.41 and p < 0.0001). Seasonality effects also contribute to additional price variability. Hypothesis 3 that $\beta_{21} = \beta_{22} = \beta_{23} = 0$ is rejected concluding CME Fats Daily Futures price adjustment does not neutralize seasonality effects on price (F = 1718.52 and p < 0.0001).

Parameter estimates represent the value of an individual characteristic as a component of total fed cattle price in dollars per hundredweight. Evaluation of all coefficients' p-values at a 5% significance level indicates only $W_{50}$ is not statistically significant. Signs for USDA quality grade parameter estimates matched expectations, demonstrating most grades below USDA Average Choice were discounted while grades above USDA Average Choice received premiums. Discounts for USDA Standard, Low, and High Select were -$18.39, -$7.69, and -$7.74 while premiums for Low Choice, Low Prime, Average, and High Prime were $0.72, $8.04, $5.53, $6.17, respectively. Signs for USDA yield grades below USDA yield grade 3 did not match expectations. USDA yield grades 1 and 2 were expected to be positive but instead were negative, suggesting buyers value cattle more at the reference category, USDA yield grade 3. Signs for yield grade estimates higher than USDA yield grade 3 matched the anticipated response. USDA yield grades 4, 5, and 6 did have expected increased negative estimates of -$1.64, -$4.72, and -$10.59. USDA yield grade 6 has a higher margin of discounts compared to USDA yield grade 5, implying the negative impact on producer price for pushing cattle to a farther endpoint. Producers will put cattle for more days on feed to reach their genetic potential and claim higher USDA quality grades but must maintain a delicate balance to avoid receiving higher USDA yield grades. Ribeye area and dressing percentage were positive as expected at $0.55 and $1.86. The slight negative estimate for heifers of -$0.82 was expected when compared to steer counterparts. Estimate signs for harvest date quarters were as anticipated for $Q_2$, but not for $Q_4$. Cattle harvested in $Q_2$ and $Q_3$ had positive estimates of $5.83 and $2.73 while cattle harvested in $Q_4$ had a discount of -$2.11, all when compared to $Q_1$. Historical beef demand is highest in $Q_2$ and $Q_4$ for summer and winter holidays, which makes a negative estimate for cattle harvested in $Q_4$ surprising (Peel, 2019). Analysis was completed for fed cattle prices instead of retail beef prices which could explain this result.

Parameter estimates for cattle with $W_{50}$, $W_{25}$, and $W_{12.5}$ of Wagyu genetics are positive at $1.58, $0.50, and $1.43, indicating price premiums exist for Wangus cattle over Angus cattle. As mentioned previously, $W_{50}$'s coefficient is not statistically significant, meaning there is not additional value in marketing the Wagyu name for this group of Wangus cattle compared to Angus. There is a smaller sample size of $W_{50}$ in comparison to $W_{25}$ and $W_{12.5}$ because the feedlot concentrates at producing cattle at $W_{25}$. Given the focus of these fed cattle buyers to acquire cattle reaching USDA Prime quality grades, they have not been focusing on American Wagyu marketing. This context helps explain the lack of statistical significance for $W_{50}$. Positive and significant estimates for $W_{25}$ and $W_{12.5}$ suggest intrinsic value in the Wagyu name association in addition to value of carcass characteristics. Results also indicate there are premiums associated with cattle below $W_{50}$ even though they cannot be marketed as American Wagyu. This is a positive outcome for producers who may want to integrate smaller percentages of Wagyu genetics into their herds with the possibility of securing premiums from these cattle.

Producers indicate Wagyu premiums and higher rates of USDA Prime cattle drives their production decisions. Results suggest value differences between USDA Prime and Choice grading cattle are $7.92 per hundredweight between the means, without considering other factors that might influence sales price (Figure 1). Figure 1 is a schematic box and whisker plot. Box plots are a graphic tool to display data with medians, means, quartiles, outliers, minimum and maximum observations (Liu, 2008). A diamond in the box represents the mean while the line within the box represents the data median. Liu (2008) explains the box contains 50% of data where the upper boundary is quartile three and lower boundary is quartile one. Length of the box is known as the interquartile range which equals quartile three minus quartile one. Whiskers extend from the box to fences which are designated at 1.5 times the interquartile range. The upper fence is above quartile three and lower fence is below quartile one. Outliers are distinguished as circles outside of fences. Figures 2 and 3 illustrate USDA AMS specification differences of marbling for USDA Average Prime (moderately abundant marbling score) and USDA Average Choice (modest marbling score) quality grades. While 20% of purebred Angus cattle from this feedlot graded prime, 60% of both $W_{50}$ and $W_{25}$ fed cattle graded prime and almost 50% of $W_{12.5}$ fed cattle achieved prime (Table 3). These figures and table demonstrate premiums available for prime grading cattle as well as influence of Wagyu genetics on achieving higher USDA quality grades.

Evaluating the combined effect of Wagyu genetics level and USDA quality grades or yield grades can help producers understand value differences of different combinations, since producers experience price differences based on favorable or unfavorable USDA quality or yield grades achieved by their cattle. Results from Table 4 are used to simulate differences in value in dollars per hundredweight across Wagyu percentages, as USDA quality grade changes while all other factors remain constant. Equation (10) shows how these value differences were calculated:

$$(10) \qquad Value\ Difference = Wagyu\ \%\ Estimate + USDA\ Quality\ Grade\ Estimate$$

Results show the highest discount is -\$17.89 for USDA Standard quality grade at $W_{25}$. The largest significant positive outcome is \$9.47 for USDA Low Prime quality grade at $W_{12.5}$ (Table 4). Recall $W_{50}$ coefficient was not statistically significant. Thus, its interactions with USDA quality grade may not be reliable. There is a positive interaction for combined effects between Wagyu genetics and USDA quality grades, which impacts producer premiums. These simulations illustrate the range of possibilities for value based on the degree of Wagyu genetics and the USDA grade achieved.

Table 5 uses a similar simulation to show differences in value in dollars per hundredweight across Wagyu percentages as USDA yield grade changes with all other variables remaining constant as shown in equation (11) below.

$$(11) \qquad Value\ Difference = Wagyu\ \%\ Estimate + USDA\ Yield\ Grade\ Estimate$$

Results report the highest significant positive outcome is \$1.43 for the reference category, USDA yield grade 3, at $W_{12.5}$. Given, recognition of the $W_{50}$ parameter estimate was not statistically significant and its interactions with USDA yield grade may not be reliable. The highest discounts are not surprisingly -\$10.09 for USDA yield grade 6 at $W_{25}$. Unlike the interaction of USDA quality grades and Wagyu influence, USDA yield grades and Wagyu genetics may have an inverse relationship. If Wangus cattle require more days on feed, this could result in higher yield grades and lead to more discounts. Premium margins for USDA Prime quality grades demonstrate producers should focus on obtaining higher quality over yield. Both Table 4 and Table 5 assist with expectations of what premiums or discounts are available for Wangus cattle at varying genetics, quality, and yield grade combinations.

**Conclusions**

Ultimately, the goal of this research is to provide a stronger understanding of potential price benefits from product differentiation of Wangus fed cattle. Using a hedonic pricing model, this analysis explored influence of varying Wagyu beef genetics on producer price for fed Angus and Wangus cattle. As expected, results suggest the market will reward producers for high USDA quality grades, larger ribeye areas, and high dressing percentages. Seasonality also imposed impacts on fed cattle prices. Positive estimates for Wagyu genetics influence indicate price premiums exist for fed Wangus cattle in addition to any premiums attributable to differences in carcass characteristics. Even though results from $W_{50}$ in this case study were not statistically significant, it is surprising but could be due to the feedlot and fed cattle buyers' focus on producing and marketing a higher percentage of prime instead of American Wagyu. While cattle with less than $W_{50}$ may not have American Wagyu marketing advantages, producers may receive premiums from these cattle based on buyers' perceptions. Favorable perceptions of Wagyu genetics are from increased beef palatability and marbling along with premiums for a higher rate of cattle achieving USDA Prime quality grades. Results demonstrate Wangus cattle graded prime at two to three times more often than Angus counterparts. Based on value difference results from interactions of Wagyu genetics with USDA quality and yield grade, producers should focus efforts on achieving USDA Prime quality grades over more desirable USDA yield grades. This study can inform the decision-making of producers considering adoption of Wagyu-influenced genetics. However, premiums alone do not dictate profit and this study does not measure profitability. Therefore, further research is needed to evaluate costs of producing Wangus cattle and to assess profitability across differing genetic combinations.

## Tables

Table 2.1. Definitions of Variables and Summary Statistics (n = 17253)

| Variable | Description | Units | Mean | Std. dev. | Min. | Max. |
|---|---|---|---|---|---|---|
| $\boldsymbol{W_{12.5}}$ | 12.5% Wagyu | 1= Yes; 0 = Otherwise | 0.035 | | 0 | 1 |
| $\boldsymbol{W_{25}}$ | 25% Wagyu | 1= Yes; 0 = Otherwise | 0.094 | | 0 | 1 |
| $\boldsymbol{W_{50}}$ | 50% Wagyu | 1= Yes; 0 = Otherwise | 0.002 | | 0 | 1 |
| $\boldsymbol{A}$ | Angus | 1= Yes; 0 = Otherwise | 0.870 | | 0 | 1 |
| | | | | | | |
| | USDA Quality Grade | | | | | |
| $\boldsymbol{ST}$ | Standard | 1= Yes; 0 = Otherwise | 0.003 | | 0 | 1 |
| $\boldsymbol{SE_L}$ | Low Select | 1= Yes; 0 = Otherwise | 0.001 | | 0 | 1 |
| $\boldsymbol{SE_H}$ | High Select | 1= Yes; 0 = Otherwise | 0.018 | | 0 | 1 |
| $\boldsymbol{CH_L}$ | Low Choice | 1= Yes; 0 = Otherwise | 0.088 | | 0 | 1 |
| $\boldsymbol{CH_A}$ | Average Choice | 1= Yes; 0 = Otherwise | 0.524 | | 0 | 1 |
| $\boldsymbol{CH_H}$ | High Choice | 1= Yes; 0 = Otherwise | 0.117 | | 0 | 1 |
| $\boldsymbol{PR_L}$ | Low Prime | 1= Yes; 0 = Otherwise | 0.104 | | 0 | 1 |
| $\boldsymbol{PR_A}$ | Average Prime | 1= Yes; 0 = Otherwise | 0.142 | | 0 | 1 |
| $\boldsymbol{PR_H}$ | High Prime | 1= Yes; 0 = Otherwise | 0.003 | | 0 | 1 |
| | | | | | | |
| | USDA Yield Grade | | | | | |
| $\boldsymbol{YG1}$ | 1 | 1= Yes; 0 = Otherwise | 0.004 | | 0 | 1 |
| $\boldsymbol{YG2}$ | 2 | 1= Yes; 0 = Otherwise | 0.101 | | 0 | 1 |
| $\boldsymbol{YG3}$ | 3 | 1= Yes; 0 = Otherwise | 0.467 | | 0 | 1 |
| $\boldsymbol{YG4}$ | 4 | 1= Yes; 0 = Otherwise | 0.355 | | 0 | 1 |
| $\boldsymbol{YG5}$ | 5 | 1= Yes; 0 = Otherwise | 0.070 | | 0 | 1 |
| $\boldsymbol{YG6}$ | 6 | 1= Yes; 0 = Otherwise | 0.004 | | 0 | 1 |
| | | | | | | |
| $\boldsymbol{DP}$ | Dressing Percentage | 0-100 | 62.24 | 2.00 | 50.46 | 74.15 |

| | | | | | | |
|---|---|---|---|---|---|---|
| $\boldsymbol{REA}$ | Ribeye Area | Inches squared (in.$^2$) | 13.68 | 1.40 | 8.49 | 22.95 |
| $\boldsymbol{H}$ | Heifer | 1= Yes; 0 = Otherwise | 0.24 | | 0 | 1 |
| $\boldsymbol{S}$ | Steer | 1= Yes; 0 = Otherwise | 0.76 | | 0 | 1 |
| $\boldsymbol{Q_1}$ | Harvest Date Quarter 1 | 1= Yes; 0 = Otherwise | 0.305 | | 0 | 1 |
| $\boldsymbol{Q_2}$ | Harvest Date Quarter 2 | 1= Yes; 0 = Otherwise | 0.293 | | 0 | 1 |
| $\boldsymbol{Q_3}$ | Harvest Date Quarter 3 | 1= Yes; 0 = Otherwise | 0.148 | | 0 | 1 |
| $\boldsymbol{Q_4}$ | Harvest Date Quarter 4 | 1= Yes; 0 = Otherwise | 0.254 | | 0 | 1 |
| $\boldsymbol{SP}$ | Sales Price | U.S. dollars ($) per harvested head | 1786.69 | 233.4 | 600.00 | 2679.85 |
| $\boldsymbol{PCWT}$ | Sales Price per Hundredweight | U.S dollars ($) per 100 pounds (lbs.) | 129.03 | 14.75 | 74.81 | 175.32 |
| $\boldsymbol{Basis}$ | PCWT – FCWT | U.S dollars ($) per 100 pounds (lbs.) | 4.65 | 8.78 | -38.85 | 39.71 |
| $\boldsymbol{FCWT}$ | Futures Price per Hundredweight | U.S dollars ($) per 100 pounds (lbs.) | 124.39 | 16.41 | 88.95 | 169.25 |
| $\boldsymbol{LW}$ | Live Weight | Pounds (lbs.) | 1384.88 | 90.22 | 914 | 1897 |
| $\boldsymbol{HCW}$ | Hot Carcass Weight | Pounds (lbs.) | 861.54 | 56.81 | 546 | 1139 |

Table 2.2. Coefficient Estimation for Hedonic Price Model

| Label | Variable | Estimate | p-value |
|---|---|---|---|
| $\boldsymbol{\beta_1}$ | Intercept | -120.724 | <.0001 |
| $\boldsymbol{\beta_2}$ | $W_{50}$ | 1.580 | 0.1357 |
| $\boldsymbol{\beta_3}$ | $W_{25}$ | 0.503 | 0.0015 |
| $\boldsymbol{\beta_4}$ | $W_{12.5}$ | 1.434 | <.0001 |
| $\boldsymbol{\beta_5}$ | $ST$ | -18.395 | <.0001 |
| $\boldsymbol{\beta_6}$ | $SE_L$ | -7.687 | <.0001 |
| $\boldsymbol{\beta_7}$ | $SE_H$ | -7.736 | <.0001 |
| $\boldsymbol{\beta_8}$ | $CH_L$ | 0.724 | <.0001 |
| $\boldsymbol{\beta_9}$ | $CH_H$ | 1.421 | <.0001 |
| $\boldsymbol{\beta_{10}}$ | $PR_L$ | 8.037 | <.0001 |
| $\boldsymbol{\beta_{11}}$ | $PR_A$ | 5.534 | <.0001 |
| $\boldsymbol{\beta_{12}}$ | $PR_H$ | 6.172 | <.0001 |
| $\boldsymbol{\beta_{13}}$ | $YG1$ | -1.802 | 0.0099 |
| $\boldsymbol{\beta_{14}}$ | $YG2$ | -0.465 | 0.0029 |
| $\boldsymbol{\beta_{15}}$ | $YG4$ | -1.635 | <.0001 |
| $\boldsymbol{\beta_{16}}$ | $YG5$ | -4.720 | <.0001 |
| $\boldsymbol{\beta_{17}}$ | $YG6$ | -10.590 | <.0001 |
| $\boldsymbol{\beta_{18}}$ | $DP$ | 1.859 | <.0001 |
| $\boldsymbol{\beta_{19}}$ | $REA$ | 0.549 | <.0001 |
| $\boldsymbol{\beta_{20}}$ | $H$ | -0.819 | <.0001 |
| $\boldsymbol{\beta_{21}}$ | $Q_2$ | 5.828 | <.0001 |
| $\boldsymbol{\beta_{22}}$ | $Q_3$ | 2.735 | <.0001 |
| $\boldsymbol{\beta_{23}}$ | $Q_4$ | -2.105 | <.0001 |
| | $R^2$ | 0.5957 | |
| | $Adj.R^2$ | 0.5952 | |

Table 2.3. Percent Distribution of USDA Quality Grades

| | % Prime | % Choice | % Other |
|---|---|---|---|
| Angus | 20 | 78 | 2 |
| 50% Wagyu | 68 | 32 | 0 |
| 25% Wagyu | 62 | 38 | < 1 |
| 12.5% Wagyu | 50 | 50 | < 1 |

Table 2.4. Value Differences of USDA Quality Grade at 50%, 25%, and 12.5% Wagyu, ceteris paribus

| | **Change in Basis ($/cwt.)** | | |
|---|---|---|---|
| **Quality Grade** | 50% Wagyu | 25% Wagyu | 12.5% Wagyu |
| Standard | -16.81 | -17.89 | -16.96 |
| Low Select | -6.11 | -7.18 | -6.25 |
| High Select | -6.16 | -7.23 | -6.30 |
| Low Choice | 2.30 | 1.23 | 2.16 |
| Average Choice | 1.58 | 0.58 | 1.43 |
| High Choice | 3.00 | 1.92 | 2.86 |
| Low Prime | 9.62 | 8.54 | 9.47 |
| Average Prime | 7.11 | 6.04 | 6.97 |
| High Prime | 7.75 | 6.68 | 7.61 |

Table 2.5. Value Differences of USDA Yield Grade at 50%, 25%, and 12.5% Wagyu, ceteris paribus

| | **Change in Basis ($/cwt.)** | | |
|---|---|---|---|
| **Yield Grade** | 50% Wagyu | 25% Wagyu | 12.5% Wagyu |
| YG 1 | -0.22 | -1.30 | -0.37 |
| YG 2 | 1.12 | 0.04 | 0.97 |
| YG 3 | 1.58 | 0.50 | 1.43 |
| YG 4 | -0.05 | -1.13 | -0.20 |
| YG 5 | -3.14 | -4.22 | -3.29 |
| YG 6 | -9.01 | -10.09 | -9.16 |

**Figures**

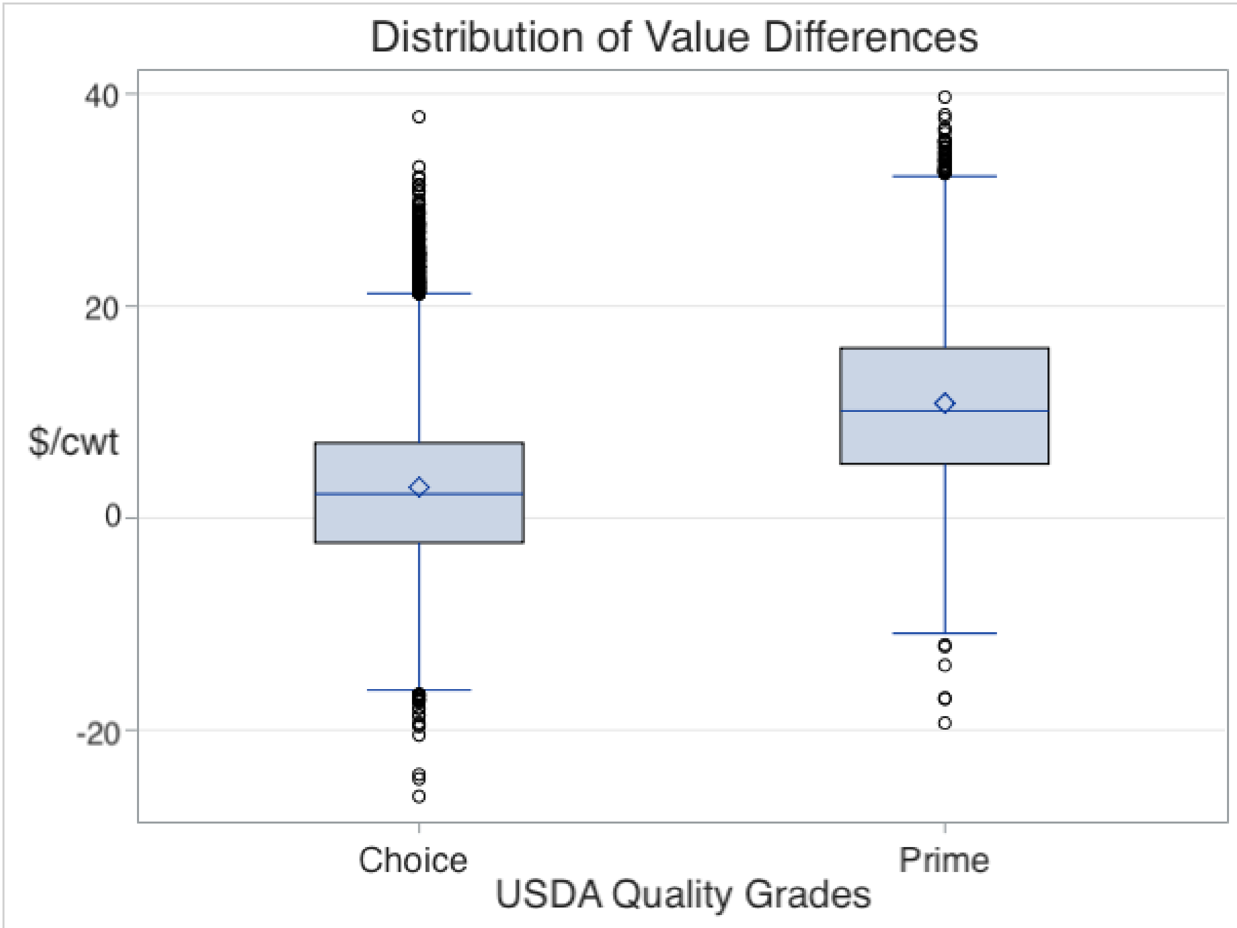


Figure 2.1. Box Plot Distribution of Value Differences between Prime and Choice Grading Cattle

Figure 2.2. USDA AMS Specification of Marbling for USDA Average Prime (Moderately Abundant Marbling Score) Quality Grade

Figure 2.3. USDA AMS Specification of Marbling for USDA Average Choice (Modest Marbling Score) Quality Grade

## REFERENCES

Hales, D.S., K. Goodson, and J.W.Savell. 2013. “USDA Beef Quality and Yield Grades.” *Texas A&M Agrilife Extension Service.* Found at: https://meat.tamu.edu/beefgrading/.

Hayes, D.J. and S.H. Lence. 2002. “A New Brand of Agriculture? Farmer-Owned Brands Reward Innovation.” *Iowa Ag Review* pp. 4-5, 8.

Iida, F., K. Saitou, T. Kawamura, S. Yamaguchi, and T. Nishimura. 2014. “Effect of Fat Content on Sensory Characteristics of Marbled Beef from Japanese Black Steers.” *Animal Science Journal* 86(7): 707-715.

Jin, Y.H., D. Zilberman, and A. Heiman. 2008. “Choosing Brands: Fresh Produce versus Other Products.” *American Journal of Agricultural Economics* 90(2): 463-475.

Liu, Y. 2008. “Box Plots: Use and Interpretation.” *Association for the Advancement of Blood & Biotherapies TRANSFUSION Journal* 48(11): 2279-2280.

Lunt, D.K., R.R. Riley, and S.B. Smith. 1993. “Growth and Carcass Characteristics of Angus and American Wagyu Steers.” *Meat Science* 34(3): 327–334.

McGee, M., C.M. Welch, J.B. Hall, W. Small, and R.A. Hill. 2013. “Evaluation of Wagyu for Residual Feed Intake: Optimizing Feed Efficiency, Growth, and Marbling in Wagyu Cattle.” *The Professional Animal Scientist* 29(1): 51-56.

Mir, P.S., D.R.C. Bailey, Z. Mir, T. Entz, S.D.M. Jones, W.M.R. Tson, R.J. Weselake, and F. J. Lozeman. 1999. “Growth, Carcass and Meat Quality Characteristics of Beef Cattle with 0, 50 and 75 Percent Wagyu Genetic Influence.” *Canadian Journal of Animal Science* 79(2): 129-137.

Mori, H., B. Lin, and W.D. Gorman. 1989. “Demand Analyses of Types of Beef in the Japanese Market: For Predicting Impacts of Trade Liberalization.” *Senshu Economic Review* pp. 1-17.

Nelson, C. 2021. “Live Animal Specification American Wagyu Association’s Specification for Characteristics of Cattle Eligible for Approved Programs Claiming Wagyu Influence.” *USDA AMS.* Available at: https://www.ams.usda.gov/sites/default/files/media/AWA_WagyuLiveAnimalSpecification.pdf.

Park, S.J., S.-H. Beak, D.J.S. Jung, S.Y. Kim, I.H. Jeong, M.Y. Piao, H.J. Kang, D.M. Fassah, S.W. Na, S.P. Yoo, and M. Baik. 2018. “Genetic, Management, and Nutritional Factors Affecting Intramuscular Fat Deposition in Beef Cattle – A Review.” *Asian-Australasian Journal of Animal Sciences* 31(7): 1043-1061.

Peel, D.S. 2019. “Holiday Beef Demand Kicks In.” *Oklahoma Cooperative Extension Service*

Cow-Calf Corner Newsletter - November 4, 2019. Found at: https://www.agproud.com/articles/53918-holiday-beef-demand-kicks-in.

Radunz, A.E., S.C. Loerch, G.D. Lowe, F.L. Fluharty, and H.N. Zerby. 2009. "Effect of Wagyu- versus Angus-sired Calves on Feedlot Performance, Carcass Characteristics, and Tenderness." *Journal of Animal Science* 87(9): 2971-2976.

Raider Red Meats. 2023. "Beef Wagyu Ribeye & Beef USDA Prime Ribeyes." *Texas Tech University.* Accessed on April 20th, 2023: https://shop.ads.ttu.edu/RaiderRedMeats.

Rosen, S. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy* 82(1): 34-55.

Smith, S.B. 2016. "Marbling and its Nutritional Impact on Risk Factors for Cardiovascular Disease." *Korean Journal for Food Science of Animal Resources* 36(4): 435-444.

Thompson, W. 2004. "Using Elasticities from an Almost Ideal Demand System? Watch Out for Group Expenditure!" *American Journal of Agricultural Economics* 86(4): 1108-1116.

USDA AMS. 2023. "Beef Grading Shields." *USDA.* Found at: https://www.ams.usda.gov/grades-standards/beef/shields-and-marbling-pictures.

Wahl, T.I., H. Shi, and R.C. Mittelhammer. 1995. "A Hedonic Price Analysis of Quality Characteristics of Japanese Wagyu Beef." *Agribusiness* 11(1): 35-44.

ZoBell, D.R., D. Whittier, and L. Holmgren. 2005. "Beef Quality and Yield Grading." *Utah State University Cooperative Extension* AG/Beef/2005-03.

# CHAPTER III

# PROFITABILITY ANALYSIS OF DIFFERING GENETIC COMBINATIONS IN WAGYU-INFLUENCED CATTLE

## Introduction

Wagyu beef is popular among U.S. consumers because of the buttery taste and tenderness associated with high amounts of marbling in its beef cuts. Research has shown Wagyu beef has a unique healthy fat composition due to higher amounts of oleic acid found in its marbling compared to marbling from traditional U.S. beef (Smith, 2018). High market prices for Wagyu and Wagyu-influenced beef have spurred some cattle producers to differentiate to increase supply for this growing market. According to Steve Bennett (2009), owner of Wagyu International and past Executive Officer in the Australian Wagyu Association, approximately 40,000 head of Wagyu and Wagyu crossbred cattle were on feed in the U.S. in 2019. To put the previous estimate in perspective, USDA (2019) reported cattle on feed in 2019 totaled 12 million head. While increasing in size since data discussed from 2019, Wagyu is still a very small market and reliable statistics are difficult to locate.

Low average daily gains and extended production cycles of Wagyu cattle have encouraged producers to crossbreed Wagyu with Angus cattle to attain these desired carcass and flavor characteristics more efficiently (Radunz et al., 2009). These offspring are known as Wangus and, through heterosis, combine distinctive carcass traits from Wagyu with the production efficiency of Angus. It is clear crossbreeding improves production efficiency relative to purebred Wagyu and improves carcass quality characteristics relative to purebred Angus. However, it is unclear how the degree of crossbreeding influences profitability across various genetic combinations.

**Objectives**

The objective is to compare feedlot profitability of Angus and Wangus cattle. Differences in feedlot profitability between different feedlot start weight groups as well as between steers and heifers will be examined. Feedlot profitability differences will also be measured across various genetic combinations, including Angus, and Wangus of 50%, 25%, and 12.5% Wagyu, noted here as $W_{50}$, $W_{25}$, and $W_{12.5}$, respectively.

**Literature Review**

Crossbreeding Wagyu with Angus is typically accomplished using Wagyu bulls with Angus females to create Wangus. First generation offspring from purebred parents, with one from each breed, are $W_{50}$ cattle. Second generation offspring are achieved by mating a first-generation offspring, $W_{50}$, with a purebred Angus resulting in $W_{25}$ cattle. Lastly, $W_{12.5}$ cattle are created from mating a second-generation offspring, $W_{25}$, with a purebred Angus. Incorporating Wagyu genetics through crossbreeding is expected to increase the percentage of prime quality grading cattle, even for lesser percentages of Wagyu influence (Mir et al., 1999). Oyama's (2011) research found heritability estimates for marbling in Wagyu cattle are approximately 0.55, which is considered a moderately to highly heritable trait. Angus' marbling heritability estimate average is 0.45 (Suther, 2009). Residual feed intake for Angus cattle is reported as moderately heritable at

0.40, but Torres-Vázquez et al. (2018) determined there is a low to moderate unfavorable genetic associations between feed efficiency traits with carcass traits such as marbling.

Radunz et al. found Wagyu-sired fed cattle graded prime at a rate of 65% compared to 21% of Angus-sired fed cattle, resulting in higher value carcasses. In their study, both groups of cattle were born from Angus cows. However, Wagyu-sired cattle were on feed for an average of 77 days longer than Angus-sired cattle. Additional days on feed may allow Wagyu to increase marbling, also known as intramuscular fat, but could potentially come at the expense of additional subcutaneous fat. Intramuscular fat is a primary factor in determining USDA quality grades for beef carcasses (Hales et al., 2013). Subcutaneous fat is external fat which is a key factor in determining USDA yield grades (ZoBell et al., 2005). Below is the USDA yield grade formula from ZoBell et al. (2005).

$$Yield\ Grade = 2.50 + (2.50 * Adjusted\ FT) + (0.20 * Percent\ KPH\ Fat) + (0.0038 * HCW) - (0.32 * REA), \quad (3)$$

where $FT$ is fat thickness in inches, $KPH$ is Kidney, Pelvic, and Heart, $HCW$ is Hot Carcass Weight in pounds, and $REA$ is Ribeye Area in inches squared. Since this equation considers many factors, it is important to note fat thickness helps determine a preliminary yield grade ($PYG$) which will be used as a base for adjustments of other traits (ZoBell et al., 2005). A PYG of 3 has 0.40 inches of external fat while a PYG of 4 is 0.80 inches and a PYG of 5 would be 1.20 inches; demonstrating how excessive amounts of subcutaneous fat contribute to yield grade discounts. Intramuscular and subcutaneous fat have an inverse relationship on price and will affect premiums available for Wagyu.

Most research to date over Wagyu cattle and beef has not studied economic viability. However, some research on differences in production efficiencies and retail product characteristics has been conducted. Early studies found Wagyu influenced cattle had lower feedlot performance and lower red meat yield compared to conventional crossbred beef cattle (Mir et al., 1999; Lunt et al., 1993). Radunz et al. (2009) noted Wagyu cattle had relatively low daily feed intake, further explaining why this breed requires more days on feed. While evidence shows Wagyu cattle achieve more desirable USDA quality grades than domestic beef breeds, potential undesirable USDA yield grades can result in discounts on carcasses (Lunt et al., 1993). McGee et al. (2013) stated more research conducted on Wagyu cattle to produce feed-efficient animals with high intramuscular fat and improved growth rates will help maximize profitability. McGee et al. (2013) and Radunz et al.'s (2009) research on production cycle differences of Wagyu cattle has also led to curiosity about whether Wagyu beef is worth the cost.

Research has shown differences exist in profitability between gender and feedlot start weights. Langemeier et al. (1992) found profitability differences for steers and heifers were mainly caused by differences in sales prices followed by feeder cattle prices and feed conversion rates. Koknaroglu et al.'s (2005) research concluded steers had higher average daily gains and tended to be more profitable than heifer counterparts. Williams et al. (1993) determined feeder cattle price differences had higher impacts on profitability for cattle with lighter feedlot start weights while fed cattle price differences had higher profitability impacts on cattle with heavier feedlot start weights. Meanwhile, Langemeier et al. (1992) deduced profit variability for cattle with lighter feedlot start weights was heavily influenced by cost of feed; cattle with heavier feedlot start weights profit variability was strongly influenced by feeder cattle prices and average daily gain. Research about Wagyu cattle stated above has only implied how differences in production cycle lengths and feed efficiencies may affect profitability (McGee et al., 2013). Recorded differences in additional days on feed and lower average daily gains exist for Wagyu-influenced cattle (i.e., Radunz et al., 2009; Lunt et al., 1993; Mir et al., 1999) although impact of these traits on profitability is likely different across various genetic combinations. Marketing opportunities are present for cattle to quality for Wagyu-influenced certified beef programs, such as American Wagyu through USDA Agricultural Marketing Service (AMS) specifications (Nelson, 2021). Price premiums from branded Wagyu programs may offset additional costs and could increase profitability.

Hayes and Lence (2002) concluded if agricultural producers embrace niche markets or strive to produce in branded programs, there could be opportunities for consumers to pay extra production costs. Morrison and Eastburn (2006) conducted a study of brand value in a commodity market, specifically focusing on branded beef products. They found a market exists for premium-priced branded beef products and perceived quality of the brand will affect brand equity (Morrison and Eastburn, 2006). Specialty beef brands such as Certified Angus Beef and Snake River Farms are prime examples of differentiated products garnering price premiums that consumers invest in through today's high beef market demand. This research builds on existing literature by comparing feedlot profitability of Angus and Wangus cattle and determining if price premiums available for this niche market support implied additional costs.

## Data

Data is sourced from a specialty ranch in the Midwest that produces Angus and Wangus cattle and grows them to harvest weight in their own feedlot before marketing the cattle. Data contain 17,763 observations composed of 15,457 Angus and 2,306 Wangus cattle. Wangus observations include cattle of $W_{50}$, $W_{25}$, and $W_{12.5}$ genetics. Variables in this data include gender, feedlot start weight, feedlot start date, days on feed (DOF), average daily gain (ADG), harvest weight, sales price, feed rations and costs, and degree of Wagyu influence. There is no transfer price associated with calves when they move from the cow-calf segment into the feedlot. To remedy this, weekly feeder cattle USDA Agricultural Marketing Service (AMS) data from the Oklahoma City market were acquired from the Livestock Marketing Information Center (LMIC) to assign transfer prices to incoming calves based on feedlot start date, feedlot start weight and gender. Prices are reported in 50 pound-increments. Transfer prices were calculated on a linear price slide using midpoints of 50-pound increments as shown in equation (2):

$$(2) \qquad \frac{(w_c - w_l)}{50} * Pw_u + \frac{(w_u - w_c)}{50} * Pw_l,$$

where $w_c$ is calf feedlot start weight, $w_l$ is lower weight midpoint, $w_u$ is upper weight midpoint, $Pw_u$ is price in dollars per hundredweight of the upper weight midpoint, and $Pw_l$ is price in dollars per hundredweight of the lower weight midpoint. Prices for upper and lower midpoints are determined from the corresponding feedlot start date or date immediately prior. For example, if a steer calf's feedlot start weight is 502 pounds, $w_l$ is 475 pounds and $w_u$ is 525 pounds. With a feedlot start date of September 4th, 2012, $Pw_l$ is \$156.48 per hundredweight and $Pw_u$ is \$150.26 resulting in a transfer price of \$153.12 per hundredweight. Microsoft Excel VBA code assisted with mimicking price slides with midpoints in 100-pound increments for cattle missing a price in either the lower or upper weight bracket but had a price in the next adjacent 50-pound category. Considering the example above for this scenario, if a price was missing for the 450 to 500-pound bracket but there was a price recorded in the 400 to 450-pound bracket, the equation becomes: $\frac{(w_c - w_l)}{100} * Pw_u + \frac{(w_u - w_c)}{50} * Pw_l$ with a new $w_l$ of 425 pounds and the corresponding $Pw_l$. Cattle with missing prices in their respective weight bracket or adjacent brackets, where a larger price slide could not be calculated, were omitted. Cattle feedlot start weights ranged between 244 and 1,298 pounds based on available data for feeder cattle prices. To get transfer price per head ($TP_i$), transfer price in dollars per hundredweight was multiplied by feedlot start weight divided by 100 in SAS 9.4.

The impact of potential data errors and statistical outliers is minimized by deleting both top and bottom 0.5% of observations for adjusted net returns. After removing these observations, ADG was examined under normal distribution shown in Figure 1. Observations outside of three standard deviations ($ADG_\mu \pm 3\sigma$) were considered outliers and removed (Stevens, 2009). Figure 2 illustrates – after outliers were removed – differences in average daily gain between genetic combinations with Wangus cattle gaining less pounds per day compared to Angus counterparts. Days on feed is increased for Wangus cattle when comparing to Angus which further supports potential differences in feedlot profitability (Figure 3). Usable observations total 16,160 head with 13,986 Angus cattle and 2,174 Wangus cattle.

Feed costs are recorded in September 2022 prices. Since feedlot data range over an eight-year period from 2012 to 2020 for feedlot start date, feed costs are adjusted to the appropriate time period using a monthly Corn Producer Price Index sourced from Federal Reserve Economic Data (FRED). Monthly Slaughter Cattle Producer Price Index was also acquired from FRED for adjustment of net returns from nominal dollars to real dollars.

**Methods & Procedures**

Net returns are modelled for the $i$th observation as a function of sales price ($SP$), transfer price ($TP$), feed cost ($FC$), and yardage cost ($YC$) in equation (3):

(3) $$NR_i = SP_i - TP_i - FC_i - YC_i$$

Observations are on a per head basis. Feed costs are based on feedlot protocols, NRC (National Research Council) nutrient requirements of Beef Cattle, and length of time on each ration. The feedlot provided information regarding feed ingredients used in each ration, total ingredient costs, and pounds given on an as fed basis per head per day for each ration. This information was used to calculate cost per pound of each ration per head per day on an as fed basis. Feedlot protocol dictated how many days cattle were on each ration: starter ($S$), grower 1 ($G1$), grower 2 ($G2$), and finisher ($F$). When cattle first arrive at the feedlot, they receive the $S$ ration for 14 days and then transition to the $G1$ ration for another 14 days. $G2$ ration is used for another 14 days and cattle then transition to the $F$ diet for their remaining days in the feedlot. Ration protocols adjusts cattle’s palette and digestive system from a forage heavy diet to a higher grain diet. A starter ration has higher hay and roughage content to mimic forages most calves from the cow-calf sector are accustomed to eating. $G1$ and $G2$ diets increase amount of grain fed at a gradual rate to obtain the level provided in a $F$ diet. A $F$ diet is composed of high amounts of processed grain such as steamrolled or cracked corn. Ration assumptions for days on feed were multiplied by cost per pound of the ration and animal start weight when receiving a specific ration while considering average daily gain from transitioning to the next ration. The NRC nutrient requirement of beef cattle is given as 0.029 times body weight in pounds of feed on an as fed basis and was used in calculations for ration cost (National Academies of Sciences, Engineering, and Medicine, 2016). Cost of each ration for each animal is denoted as $S_{cost_i}$, $G1_{cost_i}$, $G2_{cost_i}$, and $F_{cost_i}$ below.

(4) $$S_{cost_i} = Feedlot\ Start\ Weight * 0.029 * \frac{\$}{lb.} of\ feed * 14$$

(5) $$G1_{cost_i} = (Feedlot\ Start\ Weight + 14 * ADG) * 0.029 * \frac{\$}{lb.} of\ feed * 14$$

(6) $$G2_{cost_i} = (G1\ Start\ Weight + 14 * ADG) * 0.029 * \frac{\$}{lb.} of\ feed * 14$$

(7) $$F_{cost_i} = \left[\frac{Harvest\ Weight - (G2\ Start\ Weight + 14 * ADG)}{2}\right] * 0.029 * \frac{\$}{lb.} of\ feed * (DOF - 42)$$

The sum of these four ration costs equals total feed cost ($FC_i$) for each animal $i$.

Feedlot ration base price is calculated for September 2022. Nominal feed cost is created by indexing total feed cost to corn price. A six-month moving average of corn producer price index was created for range of feedlot start dates. Feedlot start date was assigned as month $t$ and monthly corn price index was used as shown below to calculate the moving average in equation (8).

(8) $$CP_{avg_t} = \frac{CP_{t-3}+CP_{t-2}+CP_{t-1}+CP_t+CP_{t+1}+CP_{t+2}}{6}$$

This corn price structure accounts for some pre-purchased feed ingredients. Transformations to adjust feed costs based on the six-month moving average corn price index were completed in SAS 9.4 using equation (9):

(9) $$FC_i^{adj} = FC_i * \frac{CP_{avg_t}}{CP_{9/2022}}.$$

Yardage costs ($YC$) include anything not accounted for in feed costs such as labor, medicine, and feedlot overhead. Many feedlot operations will charge a daily yardage fee ($YF$) to account for these various costs on a dollars per head per day basis (Lardy, 2018). Feedlot data did not include daily yardage fee estimates so an assumption of 40 cents per head per day is used from Lardy's study of custom feeding costs (2018). The yardage cost formula for an individual animal $i$ is:

(10) $$YC_i = YF * DOF_i .$$

To this point, net returns are calculated in nominal dollars. Net returns are transformed using slaughter cattle producer price index ($SCP$) to obtain values in real dollars as seen in equation (11):

(11) $$NR_i^{adj} = NR_i * \frac{SCP_{HD}}{SCP_{9/2022}},$$

where $SCP_{HD}$ is slaughter cattle producer price index value corresponding to the animal's harvest date month and $SCP_{9/2022}$ is slaughter cattle producer price index base in September 2022 prices, the same month associated with feed value prices.

This analysis will use Analysis of Variance (ANOVA) procedures and F-tests to evaluate differences in net returns across sex, feedlot start weight groups, and across genetic combinations of Angus and Wangus cattle in SAS 9.4. An ANOVA measures the ratio of variability across groups versus variability present within those groups (Smalheiser, 2017). Variability within groups is measured as sum of squares divided by its respective degrees of freedom shown as:

(12) $SS_w/df_w$

(13) $df_w = nk - k,$

where $w$ represents within groups, $n$ is number of observations, and $k$ is number of groups. Variability across groups is determined by dividing mean sum of squares by its corresponding degrees of freedom as displayed below:

(14) $SS_a/df_a$

(15) $df_a = k - 1,$

where $a$ is across groups and $k$ is number of groups. Ratio of variability is computed by dividing across groups variability by within group variability denoted as:

(16) $\frac{(SS_a/df_a)}{(SS_w/df_w)}$ .

Once an ANOVA measures variability ratio for both across and within groups, an F-distribution is used to determine statistical significance of the following hypotheses:

(17) $H_0: Means\ of\ Adjusted\ Net\ Returns\ are\ equal\ across\ the\ group$

$H_A: Means\ of\ Adjusted\ Net\ Returns\ are\ not\ equal\ across\ the\ group$

The ANOVA procedure can further implement a post hoc test for pairwise comparisons of means across subsets of data (McHugh, 2011). McHugh (2011) describes Tukey's HSD (Honestly Significant Difference) method, a post hoc test using the studentized range distribution, as a multiple comparison analysis test useful for analyzing pairwise differences when there are unequal observation sizes in subgroups within a larger group. Compared to other post hoc tests, Tukey's HSD test is more likely to identify statistically significant differences because of its use of conservative confidence intervals (Benjamini and Braun, 2002). Tukey's hypothesis for pairwise differences is expressed below:

(18) $$H_0: Mean_i = Mean_j$$

$$H_A: Mean_i \neq Mean_j,$$

where $i$ and $j$ are subgroups within a larger group.

**Results & Discussion**

*All Cattle – Genetic Combinations*

Tukey's HSD test with ANOVA pairwise comparisons was conducted in SAS 9.4 to examine whether difference in average net returns exist across various data categories. The F-test rejected the null hypothesis that means of adjusted net returns are equal across genetic combinations ($F = 110.46$, $p < 0.0001$). Table 1 reports when steers and heifers are grouped together, differences in means are statistically significant between Angus and $W_{25}$, between $W_{25}$ and $W_{50}$, and between Angus and $W_{12.5}$. Based on conversations with the feedlot operators, they considered $W_{25}$ cattle to have the highest net returns. Results from this study support their claims when steers and heifers are combined.

Figure 4 is a schematic box and whisker plot showing average adjusted net returns for each genetic combination on a per head basis with Angus at \$423.03, $W_{12.5}$ at \$501.03, $W_{25}$ at \$524.50, and $W_{50}$ at \$411.67. Box plots are a graphic method to illustrate data with medians, means, quartiles, outliers, minimum and maximum observations (Liu, 2008). The diamond in the box's center represents mean of data while the line within the box represents data median. Liu (2008) explains inside the box is 50% of data where the upper boundary is quartile three and lower boundary is quartile one. Box length is known as the interquartile range which equals quartile three minus quartile one. Whiskers extend from the box to fences which are placed at 1.5 times the interquartile range. The upper fence is above quartile three and lower fence is below quartile one. Outliers are distinguished as circles outside of fences.

*All Cattle – Feedlot Start Weight Groups*

Another ANOVA procedure was completed to analyze differences in feedlot start weight. Cattle were designated as four groups by start weight: Lights (200 – 499 pounds), Medium-Lights (500 – 699 pounds), Mediums (700 – 899 pounds), and Heavys (900 – 1,299 pounds). The F-test rejected the null hypothesis that means of adjusted net returns are equal across feedlot start weight groups ($F = 209.10$, $p < 0.0001$). When steers and heifers are combined, Table 2 shows pairwise differences in means are statistically significant between all groups which was expected based on previous literature (Williams et al., 1993; Langemeier et al., 1992). Figure 5 displays average adjusted net returns on a per head basis for each feedlot start weight group with Lights at $464.71, Medium-Lights at $448.96, Mediums at $398.12, and Heavys at $234.39.

*All Cattle – Sex*

The F-test rejected the null hypothesis that means of adjusted net returns are equal across sex ($F = 0.17$, $p = 0.6785$). A comparison of adjusted net returns by sex determines there is not a statistically significant difference between overall steer and heifer profitability as illustrated in Figure 6. Table 3 reports heifers have mean net returns of $437.14 per head while steers' average is at $435.28 per head. This result was surprising because most industry research provides evidence of steers being more profitable than heifers (Koknaroglu, et al., 2005). Although there are no statistically significant differences in means for steers and heifers, effects of genetic combinations and feedlot start weight groups are also evaluated independently for both sexes.

*Heifers*

ANOVA procedures and F-tests for unequal means were completed for steers and heifers separately. For the 3,219 head of heifers, the F-test did not reject the null hypothesis that means of adjusted net returns are equal across genetic combinations (F = 2.36, p = 0.0693). But no pairwise differences in means between all genetic combinations are statistically significant at a 5% significance level (Table 4). Though heifers have a smaller sample size between the two genders, results with no significantly statistical differences between means of genetic combinations was unexpected. At $p \leq 0.10$, only the difference in means between $W_{12.5}$ and Angus is statistically significant (Table 4). Average adjusted net returns for heifers by each genetic combination on a per head basis are shown in Figure 7. Angus heifers adjusted net returns means are $433.75, $W_{12.5}$ are $487.31, $W_{25}$ are $445.94, and $W_{50}$ are $426.63.

The F-test rejected the null hypothesis that means of adjusted net returns are equal across feedlot start weights for heifers (F = 273.77, p < 0.0001). Pairwise differences in means are statistically significant between all heifer feedlot start weight groups (Table 5). All pairwise differences in mean net returns being statistically significant between feedlot start weight groups was as predicted with existing literature (Williams et al., 1993; Langemeier et al., 1992). Figure 8 illustrates heifers' average adjusted net returns for each feedlot start weight group on a per head basis. Light heifers mean adjusted net returns are $593.30, Medium-Lights are $498.02, Mediums are $392.90, and Heavys are $208.65, indicating heifer calves at lighter feedlot start weights are more profitable.

*Steers*

For the 12,941 head of steers, the F-test rejected the null hypothesis concluding means of adjusted net returns are not equal across genetic combinations (F = 133.72, p < 0.0001). Pairwise differences in means are statistically different between Angus and $W_{25}$, $W_{25}$ and $W_{12.5}$, $W_{25}$ and

$W_{50}$, and between $W_{12.5}$ and Angus (Table 6). Figure 9 has adjusted net returns of each genetic combination for steers on a per head basis. Angus steers are \$420.54, $W_{12.5}$ are \$503.96, $W_{25}$ are \$557.03, and $W_{50}$ are \$396.71, which supports feedlot operators' consideration of $W_{25}$ cattle to have the highest net returns.

F-test results reject the null hypothesis, indicating adjusted net returns means are unequal across steer feedlot start weight groups ($F = 66.57$, $p < 0.0001$). Table 7 reports differences in pairwise averages are statistically significant between all groups, as anticipated from prior research (Williams et al., 1993; Langemeier et al., 1992). Figure 10 shows steers mean adjusted net returns by feedlot start weight group with Lights at \$455.17, Medium-Lights at \$439.59, Mediums at \$401.67, and Heavys at \$265.89. Results from ANOVA procedures for steers were closer to expectations than heifer results.

In both ANOVA procedures, two Wagyu genetic combinations had higher net returns compared to Angus. Both $W_{12.5}$ and $W_{25}$ have higher average net returns than Angus on a per head basis. However, ANOVA procedures determined $W_{50}$ have the lowest average net returns among all genetic combinations for both steers and heifers with the utilized assumptions. For feedlot start weight groups, ANOVA procedures concluded for both steers and heifers, Lights had highest average net returns, then Medium-Lights, then Mediums, and Heavys had the lowest average net returns.

**Conclusions**

Differences do exist in feedlot profitability among Angus and Wangus genetics. On average, Wangus at $W_{12.5}$ and $W_{25}$ have higher net returns compared to Angus when all cattle were combined and for steers and heifers separately. These results imply additional costs of producing Wagyu cattle may be reduced with crossbreeding and Wangus crossbreds may have higher net returns than purebred or fullblood Angus cattle for some genetic combinations.

Wangus with $W_{50}$ had the lowest net returns on average, though these cattle qualify to be marketed as American Wagyu, which could be due to traits not captured in data or not included in this analysis. This could also be attributed to the objectives of this specific feedlot and their buyers, as marketing branded American Wagyu is not their goal, but rather achieving USDA Prime quality grades. While unexpected, there was no statistical difference in steer and heifer feedlot profitability. Differences also exist in profitability across feedlot start weight groups. When cattle are sorted by feedlot start weights, Lights had highest mean net returns followed by Medium-Lights, Mediums, and Heavys for all cattle and when steers and heifers were separated. Feedlots understand when taking in light weight calves that they will be in the feedlot for a longer time period versus heavier weight calves having a shorter turnover in the feedlot and seeing returns sooner but at lower levels. However, there is still value in profitability coming from cattle with heavier start weights since this study only evaluated net returns per head, not by time units associated with these cattle. There was a large range of start weights in the data, and some of the higher weights are outside of typical industry standards for cattle entering feedlots. There is also a possibility as cattle move from ranch to feedlot, transfer prices could be higher compared to the data used if Wagyu influence is valued higher in feeder calves, potentially impacting net returns. While these results do not reflect the whole industry, they do provide an insightful snapshot for individual producers or feedlots considering incorporating Wagyu genetics. This study illustrates how differentiating with Wagyu genetics for niche market premiums can offset additional costs.

Additional research could evaluate cow-calf costs prior to the feedlot stage for varying genetic combinations. Further research could expand analysis to examine influence of performance indicators, such as days on feed and average daily gain, on feedlot profitability.

**Tables**

Table 3.1. ANOVA Tukey Test for Pairwise Comparisons of Mean Adjusted Net Returns Across All Cattle for Wagyu Genetic Combinations

| $\boldsymbol{Genetic\ Combination_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Genetic\ Combination_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{W_{12.5}}$ | \$501.03 | $A$ | \$423.03 | \$78.00* |
| $\boldsymbol{W_{12.5}}$ | \$501.03 | $W_{25}$ | \$524.50 | \$23.47 |
| $\boldsymbol{W_{12.5}}$ | \$501.03 | $W_{50}$ | \$411.67 | \$89.36 |
| $\boldsymbol{W_{50}}$ | \$411.67 | $W_{25}$ | \$524.50 | \$112.83* |
| $\boldsymbol{W_{50}}$ | \$411.67 | $A$ | \$423.03 | \$11.36 |
| $\boldsymbol{W_{25}}$ | \$524.50 | $A$ | \$423.03 | \$101.47* |

* Denotes statistical significance at $\alpha = 0.05$, DF = 16155

Note: $\boldsymbol{W_{12.5}}$ = 12.5% Wagyu, $\boldsymbol{W_{25}}$ = 25% Wagyu, $W_{50}$ = 50% Wagyu, $A$ = Angus

Table 3.2. ANOVA Tukey Test for Pairwise Comparisons of Mean Adjusted Net Returns Across All Cattle for Feedlot Start Weight Groups

| $\boldsymbol{Feedlot\ Start\ Weight\ Group_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Feedlot\ Start\ Weight\ Group_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{Lights}$ | \$464.71 | $Medium - Lights$ | \$448.96 | \$15.75* |
| $\boldsymbol{Lights}$ | \$464.71 | $Mediums$ | \$398.12 | \$53.09* |
| $\boldsymbol{Lights}$ | \$464.71 | $Heavys$ | \$234.39 | \$204.01* |
| $\boldsymbol{Medium - Lights}$ | \$448.96 | $Mediums$ | \$398.12 | \$50.84* |
| $\boldsymbol{Medium - Lights}$ | \$448.96 | $Heavys$ | \$234.39 | \$214.56* |
| $\boldsymbol{Mediums}$ | \$398.12 | $Heavys$ | \$234.39 | \$163.74* |

* Denotes statistical significance at $\alpha = 0.05$, DF = 16153

Note: $Lights$ (200 – 499 pounds), $Medium - Lights$ (500 – 699 pounds), $Mediums$ (700 – 899 pounds), and $Heavys$ (900 – 1,299 pounds)

Table 3.3. ANOVA Tukey Test for Pairwise Comparison of Mean Adjusted Net Returns Across All Cattle for Sex

| $\boldsymbol{Gender_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Gender_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{Heifers}$ | $437.14 | $Steers$ | $435.29 | $1.85 |

* Denotes statistical significance at $\alpha = 0.05$, DF = 16153

Table 3.4. ANOVA Tukey Test for Pairwise Comparisons of Mean Adjusted Net Returns Across Heifers for Wagyu Genetics Combinations

| $\boldsymbol{Genetic\ Combination_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Genetic\ Combination_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{W_{12.5}}$ | $487.31 | $A$ | $433.75 | $53.56* |
| $\boldsymbol{W_{12.5}}$ | $487.31 | $W_{25}$ | $445.94 | $41.37 |
| $\boldsymbol{W_{12.5}}$ | $487.31 | $W_{50}$ | $426.63 | $60.68 |
| $\boldsymbol{W_{50}}$ | $426.63 | $W_{25}$ | $445.94 | $19.31 |
| $\boldsymbol{W_{50}}$ | $426.63 | $A$ | $433.75 | $7.12 |
| $\boldsymbol{W_{25}}$ | $445.94 | $A$ | $433.75 | $12.19 |

* Denotes statistical significance at $\alpha = 0.10$, DF = 3215

Note: $\boldsymbol{W_{12.5}}$ = 12.5% Wagyu, $\boldsymbol{W}_{25}$ = 25% Wagyu, $W_{50}$ = 50% Wagyu, $A$ = Angus

Table 3.5. ANOVA Tukey Test for Pairwise Comparisons of Mean Adjusted Net Returns Across Heifers for Feedlot Start Weight Groups

| $\boldsymbol{Feedlot\ Start\ Weight\ Group_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Feedlot\ Start\ Weight\ Group_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{Lights}$ | \$593.30 | $Medium - Lights$ | \$498.02 | \$95.28* |
| $\boldsymbol{Lights}$ | \$593.30 | $Mediums$ | \$392.90 | \$200.40* |
| $\boldsymbol{Lights}$ | \$593.30 | $Heavys$ | \$208.65 | \$384.65* |
| $\boldsymbol{Medium - Lights}$ | \$498.02 | $Mediums$ | \$392.90 | \$105.12* |
| $\boldsymbol{Medium - Lights}$ | \$498.02 | $Heavys$ | \$208.65 | \$289.38* |
| $\boldsymbol{Mediums}$ | \$392.90 | $Heavys$ | \$208.65 | \$184.25* |

* Denotes statistical significance at $\alpha = 0.05$, DF = 3215

Note: $Lights$ (200 – 499 pounds), $Medium - Lights$ (500 – 699 pounds), $Mediums$ (700 – 899 pounds), and $Heavys$ (900 – 1,299 pounds)

Table 3.6. ANOVA Tukey Test for Pairwise Comparisons of Mean Adjusted Net Returns Across Steers for Wagyu Genetics Combinations

| $\boldsymbol{Genetic\ Combination_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Genetic\ Combination_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{W_{12.5}}$ | \$503.96 | $A$ | \$420.54 | \$83.42* |
| $\boldsymbol{W_{12.5}}$ | \$503.96 | $W_{25}$ | \$557.03 | \$53.07* |
| $\boldsymbol{W_{12.5}}$ | \$503.96 | $W_{50}$ | \$396.71 | \$107.25 |
| $\boldsymbol{W_{50}}$ | \$396.71 | $W_{25}$ | \$557.03 | \$160.32* |
| $\boldsymbol{W_{50}}$ | \$396.71 | $A$ | \$420.54 | \$23.83 |
| $\boldsymbol{W_{25}}$ | \$557.03 | $A$ | \$420.54 | \$136.50* |

* Denotes statistical significance at $\alpha = 0.05$, DF = 12937

Note: $\boldsymbol{W_{12.5}}$ = 12.5% Wagyu, $\boldsymbol{W}_{25}$ = 25% Wagyu, $W_{50}$ = 50% Wagyu, $A$ = Angus

Table 3.7. ANOVA Tukey Test for Pairwise Comparisons of Mean Adjusted Net Returns Across Steers for Feedlot Start Weight Groups

| $\boldsymbol{Feedlot\ Start\ Weight\ Group_1}$ | $\boldsymbol{\mu_1}$ | $\boldsymbol{Feedlot\ Start\ Weight\ Group_2}$ | $\boldsymbol{\mu_2}$ | $\boldsymbol{Difference\ Between\ Means}$ |
|---|---|---|---|---|
| $\boldsymbol{Lights}$ | \$455.17 | $Medium - Lights$ | \$439.59 | \$15.89* |
| $\boldsymbol{Lights}$ | \$455.17 | $Mediums$ | \$401.67 | \$53.50* |
| $\boldsymbol{Lights}$ | \$455.17 | $Heavys$ | \$265.89 | \$189.28* |
| $\boldsymbol{Medium - Lights}$ | \$439.59 | $Mediums$ | \$401.67 | \$37.91* |
| $\boldsymbol{Medium - Lights}$ | \$439.59 | $Heavys$ | \$265.89 | \$173.70* |
| $\boldsymbol{Mediums}$ | \$401.67 | $Heavys$ | \$265.89 | \$135.78* |

* Denotes statistical significance at $\alpha = 0.05$, DF = 12937

Note: $Lights$ (200 – 499 pounds), $Medium - Lights$ (500 – 699 pounds), $Mediums$ (700 – 899 pounds), and $Heavys$ (900 – 1,299 pounds)

**Figures**

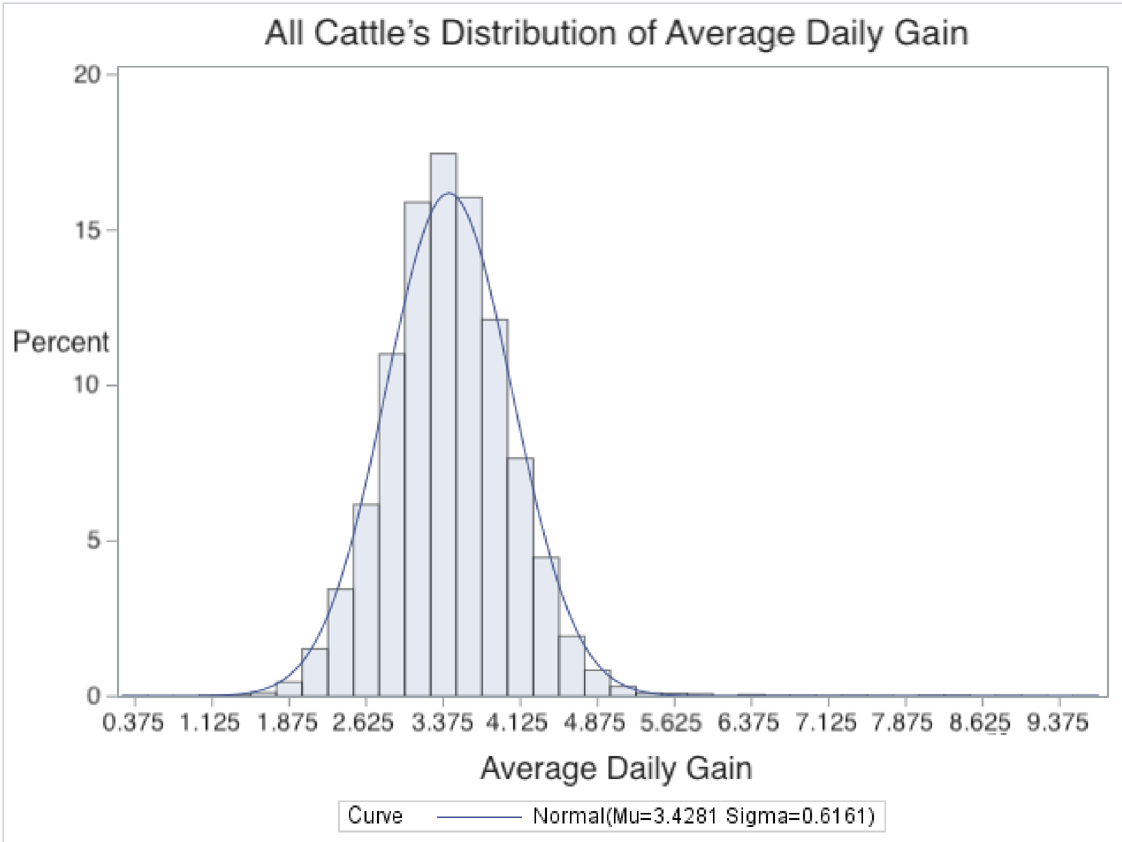


Figure 3.1. All Cattle's Distribution of Average Daily Gain Prior to Removal of Outliers

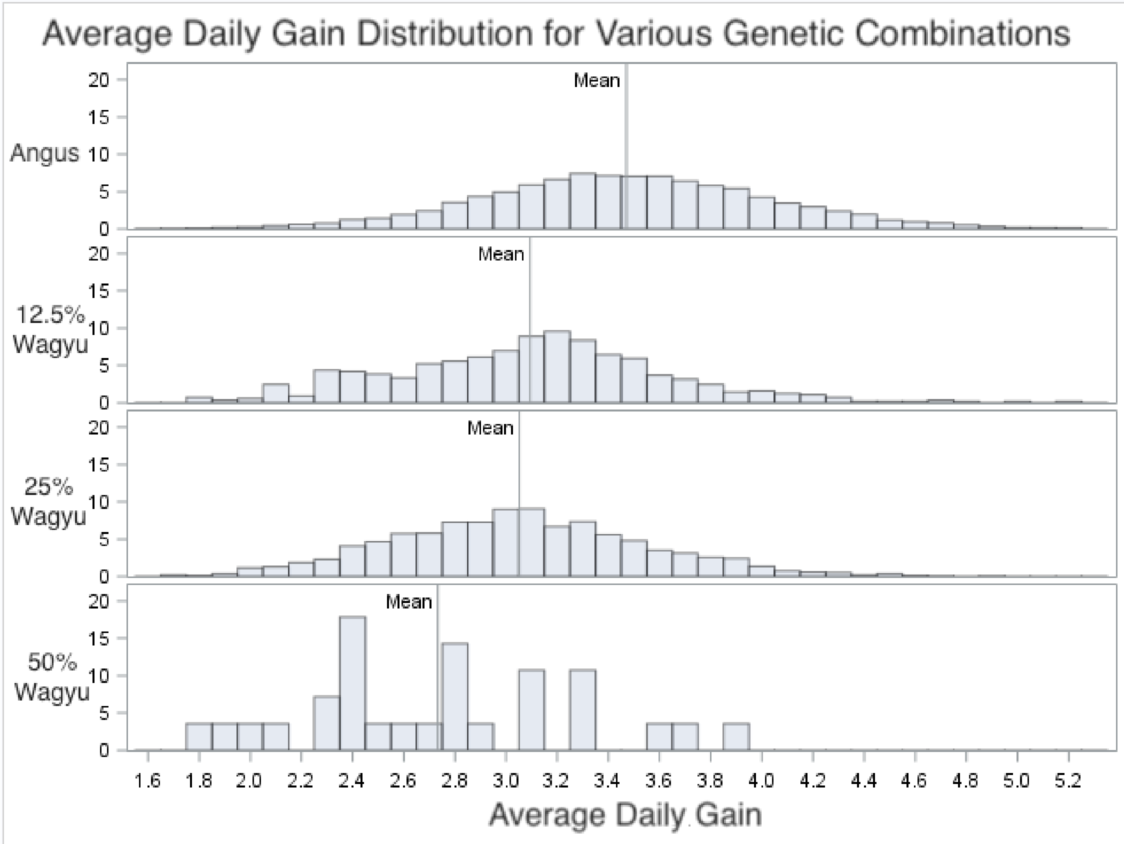


Figure 3.2. Average Daily Gain Distribution for Various Genetic Combinations

Note: Y-axis for each Genetic Combination denotes Percent of Observations

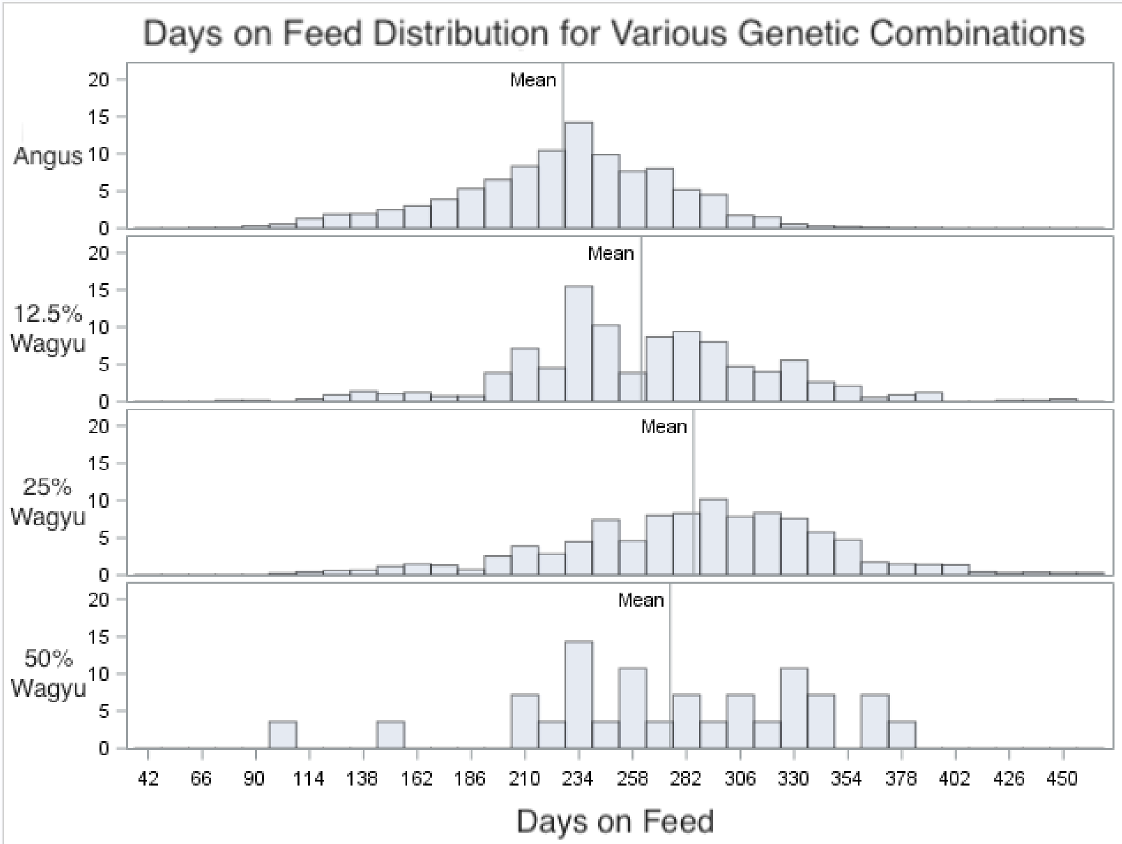


Figure 3.3. Days on Feed Distribution for Various Genetic Combinations

Note: Y-axis for each Genetic Combination denotes Percent of Observations

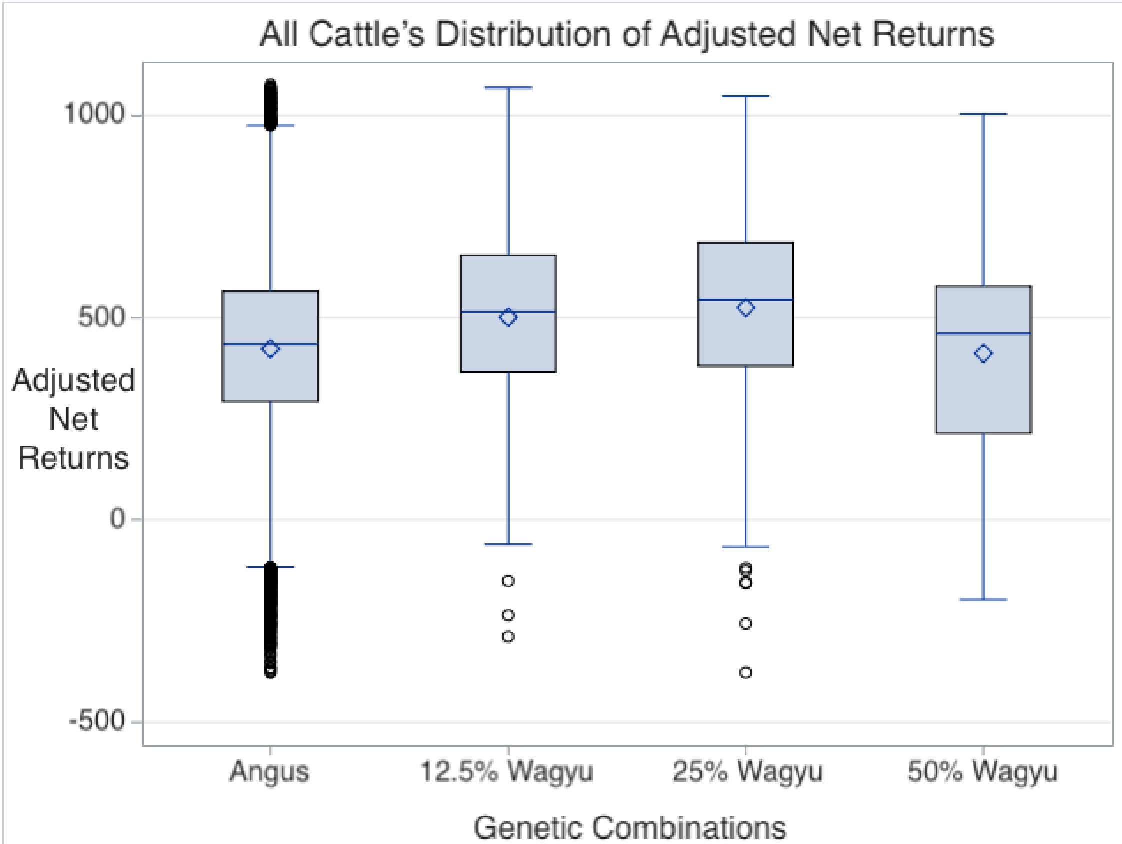


Figure 3.4. All Cattle's Distribution of Adjusted Net Returns for Various Genetic Combinations

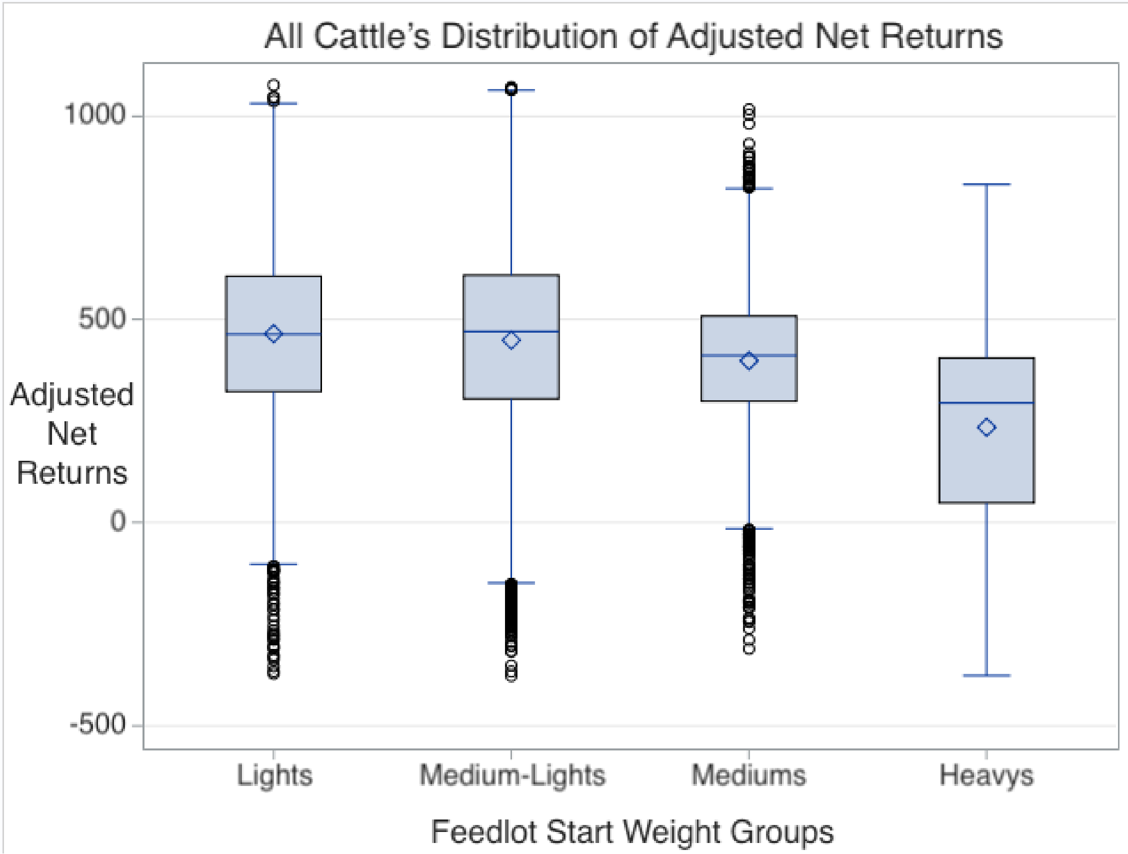


Figure 3.5. All Cattle's Distribution of Adjusted Net Returns for Various Feedlot Start Weight Groups

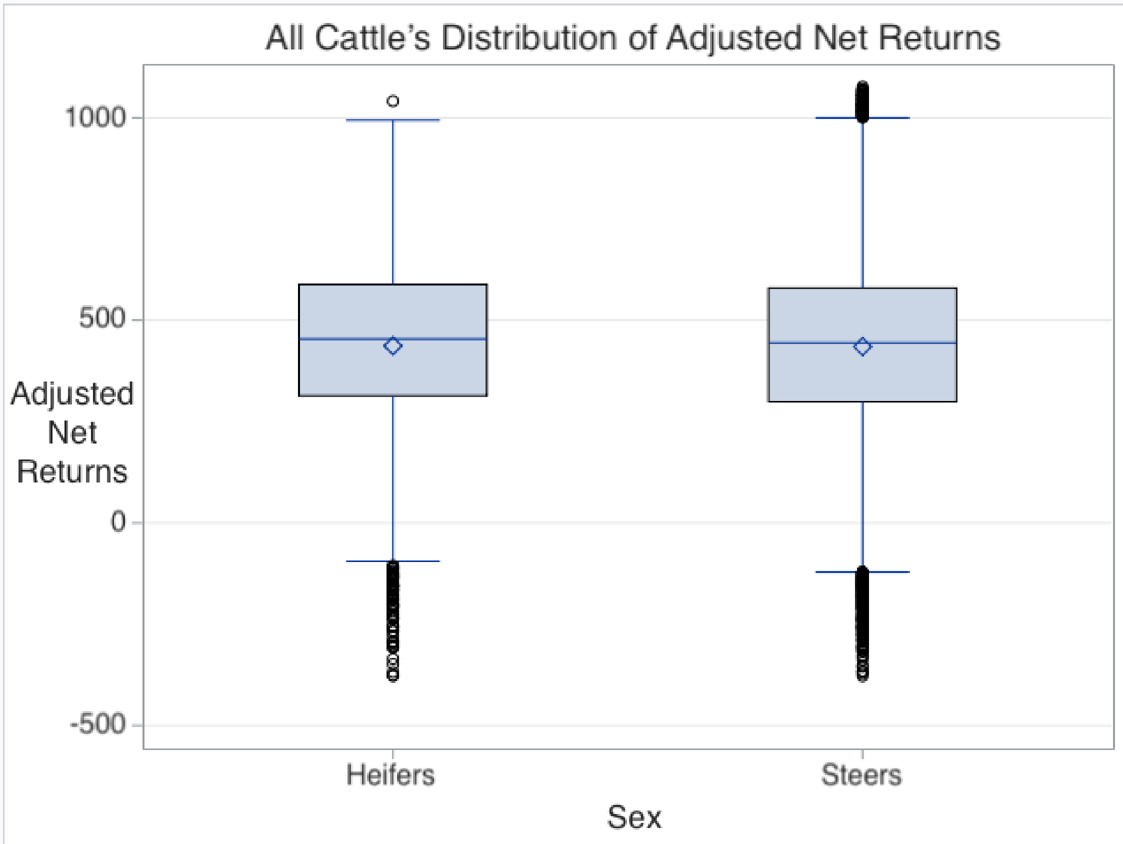


Figure 3.6. All Cattle's Distribution of Adjusted Net Returns for Sex

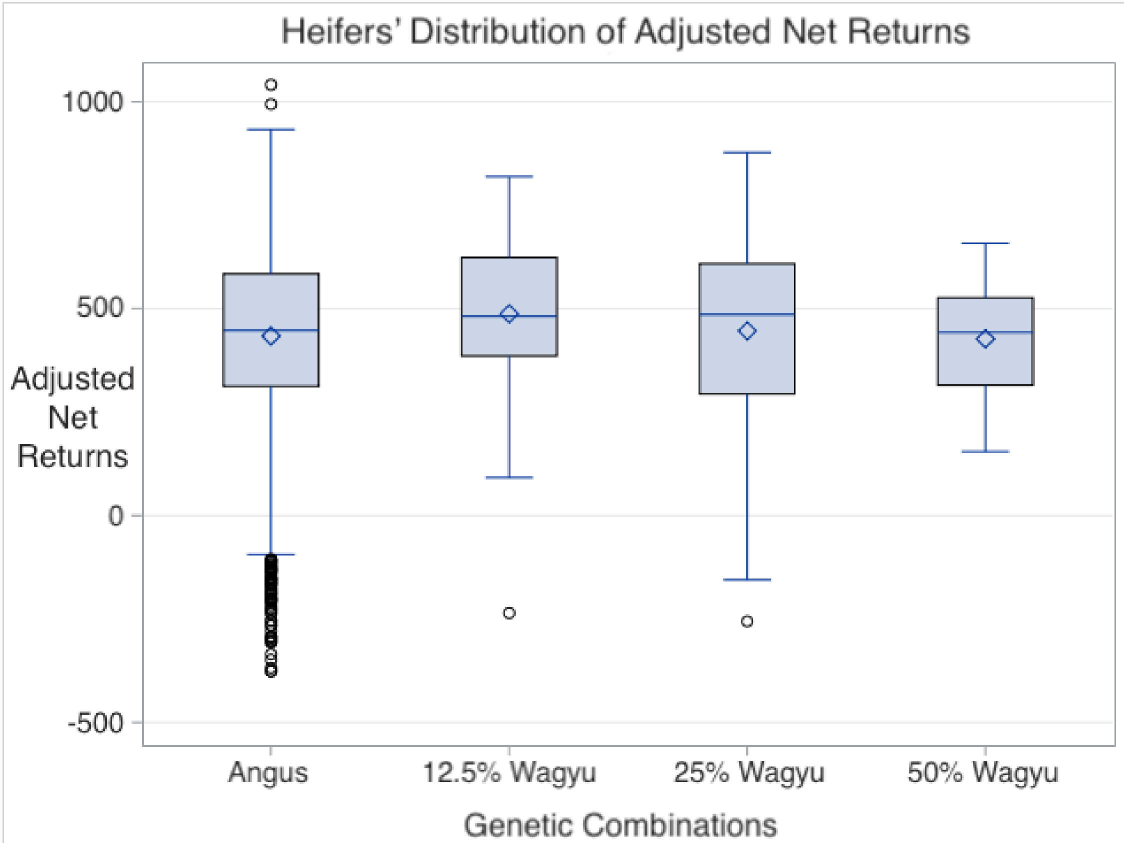


Figure 3.7. Heifers' Distribution of Adjusted Net Returns for Various Genetic Combinations

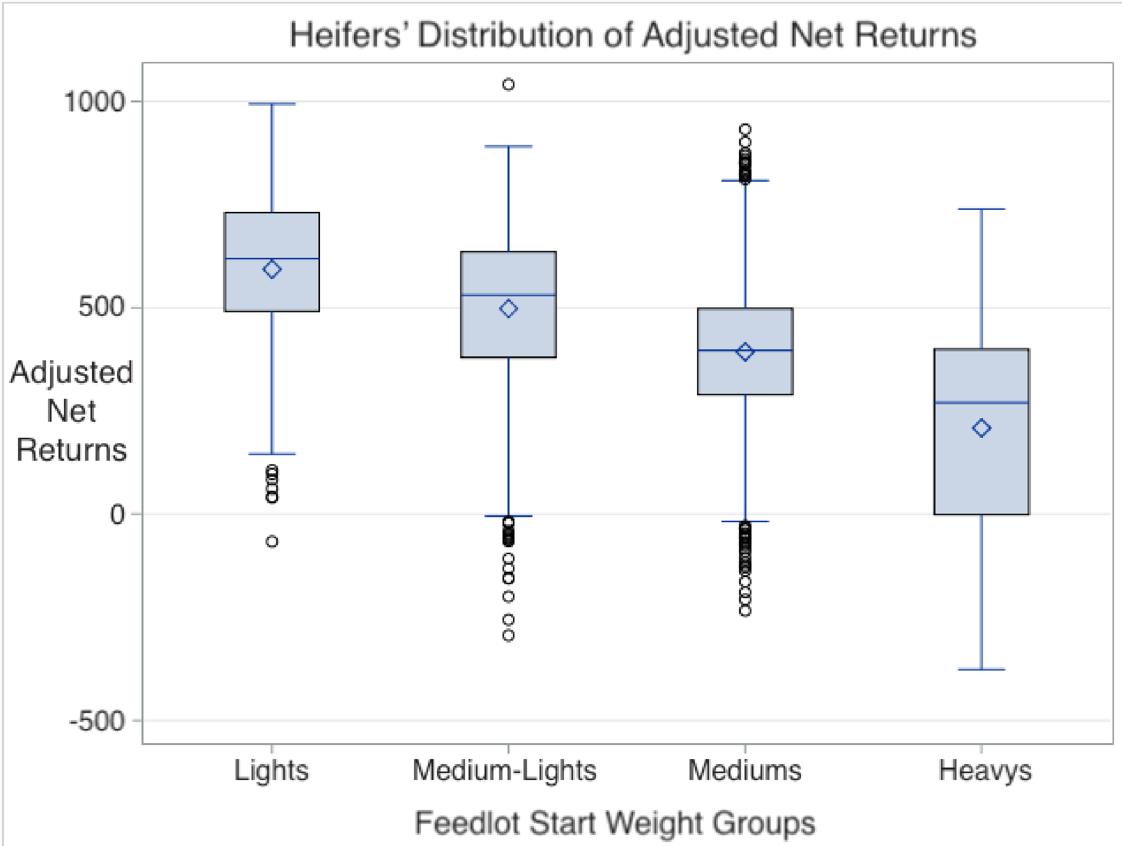


Figure 3.8. Heifers' Distribution of Adjusted Net Returns for Various Feedlot Start Weight Groups

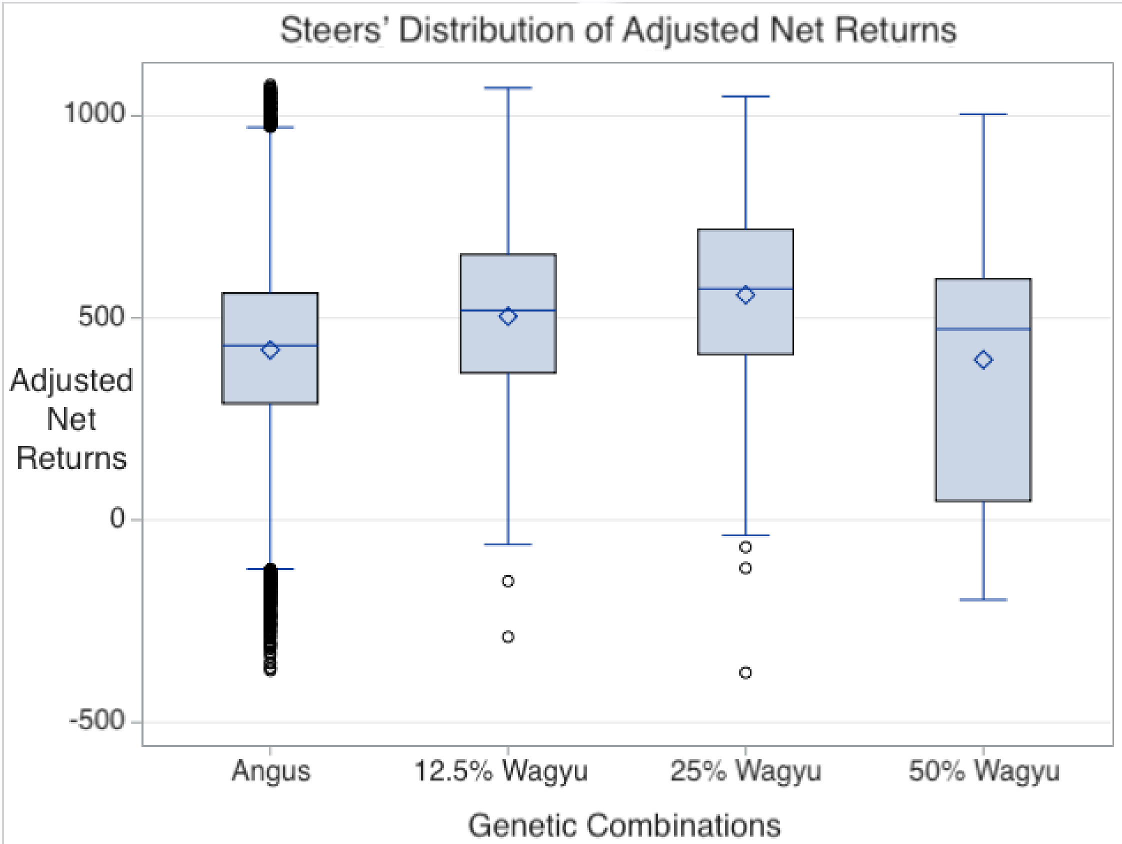


Figure 3.9. Steers' Distribution of Adjusted Net Returns for Various Genetic Combinations

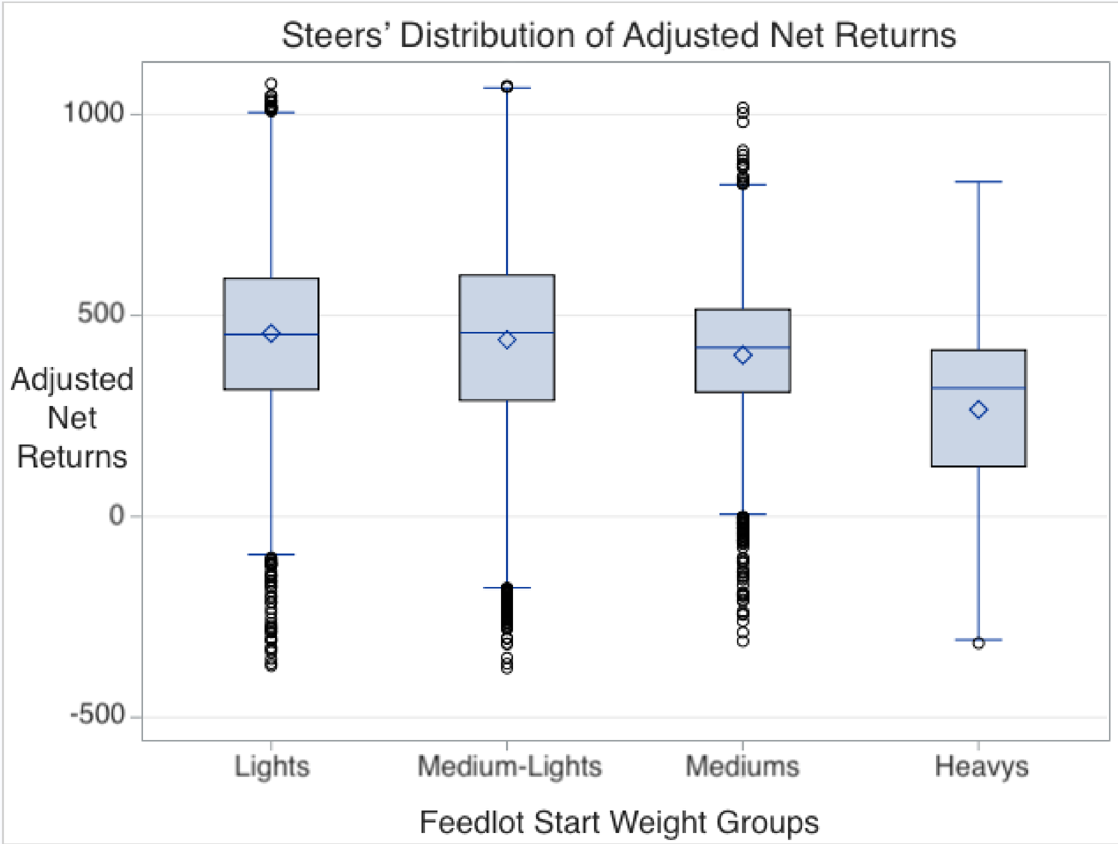


Figure 3.10. Steers' Distribution of Adjusted Net Returns for Various Feedlot Start Weight Groups

# REFERENCES


Benjamini, Y. and H. Braun. 2002. “John W. Tukey’s Contributions to Multiple Comparisons.” *The Annals of Statistics* 30(6): 1576-1594.

Bennett, S. 2019. “The Wagyu Herd in USA.” *Wagyu International*. Found at: http://www.wagyuinternational.com/global_USA.php.

Hales, D.S., K. Goodson, and J.W.Savell. 2013. “USDA Beef Quality and Yield Grades.” *Texas A&M Agrilife Extension Service.* Found at: https://meat.tamu.edu/beefgrading/.

Hayes, D.J., and S.H. Lence. 2002. “A New Brand of Agriculture? Farmer-Owned Brands Reward Innovation.” *Iowa Ag Review* pp. 4-5, 8.

Koknaroglu, H., D.D. Loy, D.E. Wilson, M.P. Hoffman, and J.D. Lawrence. 2005. “Factors Affecting Beef Cattle Performance and Profitability.” *Journal of Applied Animal Science* 21(4): 286-296.

Langemeier, M.R., J.R. Mintert, and T.C. Schroeder. 1992. “Determinants of Cattle Finishing

Profitability." *Southern Journal of Agricultural Economics* 24(2): 41-47.

Lardy, G. 2018. "A Cow-calf Producer's Guide to Custom Feeding." *NDSU Extension* AS1162.

Liu, Y. 2008. "Box Plots: Use and Interpretation." *Association for the Advancement of Blood & Biotherapies TRANSFUSION Journal* 48(11): 2279-2280.

Lunt, D.K., R.R. Riley, and S.B. Smith. 1993. "Growth and Carcass Characteristics of Angus and American Wagyu Steers." *Meat Science* 34(3): 327–334.

McGee, M., C.M. Welch, J.B. Hall, W. Small, and R.A. Hill. 2013. "Evaluation of Wagyu for Residual Feed Intake: Optimizing Feed Efficiency, Growth, and Marbling in Wagyu Cattle." *The Professional Animal Scientist* 29(1): 51-56.

McHugh, M.L. 2011. "Multiple Comparison Analysis Testing in ANOVA." *Biochemia Medica* 21(3): 203-209.

Mir, P.S., D.R.C. Bailey, Z. Mir, T. Entz, S.D.M. Jones, W.M.R. Tson, R.J. Weselake, and F. J. Lozeman. 1999. "Growth, Carcass and Meat Quality Characteristics of Beef Cattle with 0, 50 and 75 Percent Wagyu Genetic Influence." *Canadian Journal of Animal Science* 79(2): 129-137.

Morrison, M., Eastburn, M. 2006. "A Study of Brand Equity in a Commodity Market." *Australasian Marketing Journal* 14(1): 60-76.

National Academies of Sciences, Engineering, and Medicine. 2016. "Nutrient Requirements of Beef Cattle: Eighth Revised Edition." *The National Academies Press*, pp. 1-494.

Nelson, C. 2021. “Live Animal Specification American Wagyu Association’s Specification for Characteristics of Cattle Eligible for Approved Programs Claiming Wagyu Influence.” *USDA AMS.* Available at: https://www.ams.usda.gov/sites/default/files/media/AWA_WagyuLiveAnimalSpecification.pdf.

Oyama, K. 2011. “Genetic Variability of Wagyu Cattle Estimated by Statistical Approaches.” *Animal Science Journal* 82(3): 367-373.

Radunz, A.E., S.C. Loerch, G.D. Lowe, F.L. Fluharty, and H.N. Zerby. 2009. “Effect of Wagyu- versus Angus-sired Calves on Feedlot Performance, Carcass Characteristics, and Tenderness.” *Journal of Animal Science* 87(9): 2971-2976.

Smalheiser, N.R. 2017. “Data Literacy: How to Make Your Experiments Robust and Reproducible.” *Elsevier Inc.*, pp. 149-155.

Smith, S.B. 2016. “Marbling and its Nutritional Impact on Risk Factors for Cardiovascular Disease.” *Korean Journal for Food Science of Animal Resources* 36(4): 435-444.

Stevens, J.P. 2009. “Applied Multivariate Statistics for the Social Sciences: Fifth Edition.” *Routledge Taylor & Francis Group,* pp. 10-15.

Suther, S. 2009. “Genetics and Marbling.” *ANGUS Journal* September (2009): 112-113.

Torres-Vázquez, J.A., J.H.J. Van Der Werf, and S.A. Clark. 2018. “Genetic and Phenotypic Associations of Feed Efficiency with Growth and Carcass Traits in Australian Angus Cattle.” *Journal of Animal Science* 96(11): 4521-4531.

USDA. 2019. "Cattle on Feed (December 2019)." *USDA National Agricultural Statistics Service*. Found at: https://usda.library.cornell.edu/concern/publications/m326m174z?locale=en&page=5#release-items.

Williams, C.L., M.R. Langemeier, J.R. Mintert, and T.C. Schroeder. 1993. "Profitability Differences Between Steers and Heifers." *Extension Beef Cattle Resource Committee* BCH-8054: 1-4.

ZoBell, D.R., D. Whittier, and L. Holmgren. 2005. "Beef Quality and Yield Grading." *Utah State University Cooperative Extension* AG/Beef/2005-03.

# CHAPTER IV

# WARRANTING WANGUS

## Importance of Supply Chain Linkages

Even though Wagyu and Wagyu-influenced beef began as a niche market, certain aspects within this specialized supply chain can help producers succeed at differentiating outside of this niche. The unique nature of Wangus production and relationships between fed cattle buyers or Wangus bull customers adds value to Wagyu-influenced cattle coming from the specialty ranch and feedlot in this case study. As mentioned in Chapter 1, these customers' interest in Wangus was motivated by increasing the proportion of prime grading cattle rather than marketing only the association with American Wagyu. Wangus are using qualities from the niche market of Wagyu to inject unique characteristics into the commercial cattle market, enhancing profitability. Utilizing Wangus is a possible way for producers to keep their original herds and add new genetics to increase beef quality.

## Influence of Wagyu Beef Genetics on Fed Cattle Price

The goal of this research is to provide a stronger understanding of potential price benefits from product differentiation with Wangus fed cattle. A hedonic pricing model helped analyze influence of varying levels of Wagyu beef genetics on fed prices for Angus and Wangus cattle. Results indicate premiums exist not only for certain carcass attributes but also for distinction associated with Wagyu beef. Recall that Wagyu percentages of 12.5%, 25%, and 50% in these Wangus cattle are denoted as $W_{12.5}$, $W_{25}$, and $W_{50}$, respectively.

Positive and significant premiums were indicated for $W_{25}$, and $W_{12.5}$ cattle beyond value differences for carcass characteristics alone. Wangus cattle's added value may be attributed to buyer perceptions of attributes associated with the Wagyu breed or other traits not measured directly in data. Although lack of statistical significance was surprising for $W_{50}$, it could be because of the feedlot and fed cattle buyers' intentions of producing and marketing a higher percentage of prime rather than marketing American Wagyu. While $W_{25}$ and $W_{12.5}$ cattle may not have American Wagyu marketing advantages, producers may receive premiums from these cattle based on buyers' perceptions of Wagyu influence on beef palatability, marbling, and an increased rate of cattle achieving USDA Prime quality grades.

In addition to premiums for the Wangus name, significant premiums also exist for cattle that reached USDA prime quality grades. Wangus cattle graded prime two to three times more often than their Angus counterparts. Price component parameters are statistically significant ($p < 0.05$) for all carcass traits. Higher dressing percentages and bigger ribeye areas receive premiums while heifers receive slight discounts. Discounts are significant for cattle with lower red meat yield at USDA yield grades 4, 5, and 6. Seasonality effects were also statistically significant. Value difference results from interactions of Wagyu genetics with USDA quality and yield grade indicate producers should focus on achieving USDA Prime quality grades over more red meat yield. It is important to recognize the hedonic model captures price components but does not account for any differences in costs.

## Profitability Analysis of Differing Genetic Combinations in Wagyu-influenced Cattle

Feedlot profitability is measured using an analysis of adjusted net returns across feedlot start weight groups, sex, and multiple genetic combinations of Angus and Wangus cattle. The analysis found differences do exist in feedlot profitability among Angus and Wangus genetics. $W_{25}$ and $W_{12.5}$ on average have higher net returns compared to Angus when all cattle were combined and for steers and heifers separately. These results imply additional costs of Wagyu cattle may be reduced with crossbreeding and some Wangus genetic combinations may have higher net returns than purebred or fullblood Angus cattle. On average, $W_{50}$ also had the lowest net returns which could be due to characteristics of these cattle not captured in data or included in the analysis. This may also be attributed to the specialty feedlot's focus and their fed cattle buyers' focus on achieving and marketing USDA Prime quality grades instead of American Wagyu branding. Unexpectedly, there was no statistically significant difference in average profitability between steers and heifers. However, differences do exist in profitability among feedlot start weight groups. Lights had highest mean net returns followed by Medium-Lights, Mediums, and Heavys for all cattle and when steers and heifers were considered separately. This study illustrates how differentiating with Wagyu genetics to attain niche market premiums can offset implied additional costs.

## Industry Implications

Little research prior to this case study has evaluated economic costs and benefits of Wagyu-influenced cattle. Effectively estimating the benefits of producing Wangus cattle increases knowledge of all parties involved in the supply chain. This research aims to bridge that gap in economic analysis and provide more knowledge to those involved in various supply chain segments. This research focused on economic motivations, supply chain relationships, price components, availability of potential premiums, and profitability in Wangus cattle production.

Further research could evaluate costs of producing Wangus cattle at the cow-calf level. This knowledge can inform producers considering adoption of Wagyu influenced genetics. Further research is needed to examine the impact of performance indicators, such as days on feed and average daily gain, on feedlot profitability. Future research could expand the profitability analysis to examine net returns as a function of these performance indicators.

This research can help producers understand how they may capture price benefits from implementing Wagyu genetics into their herds. Results demonstrate Wangus cattle can increase the probability of cattle achieving prime quality grades, in turn then increasing the value of the cattle. Results also concluded price premiums could be achieved while minimizing losses of additional costs typically associated with Wagyu because of longer production cycles. While this case study does not reflect the whole industry, these results do provide an insightful snapshot for individual producers or feedlots that want to differentiate by incorporating Wagyu-influenced cattle.

# APPENDICES

# APPENDIX A: Survey Questions – Wangus Bull Customers

Survey Questions – Specialty Feedlot and Buyer Relationships

**Wangus Customers (Bulls/Semen)**

1.) How did you become aware of [redacted]'s operation?

2.) Describe the general business relationship you have with [redacted].

3.) Which of these phases does your operation include. Circle what applies.
    a. Seedstock
    b. Cow-Calf
    c. Stocker
    d. Feedlot/Finisher

4.) Please indicate the size of your operation and the proportion of Wagyu-influenced calves to the rest of your calf-crop on an average annual basis.
    a. Number of total calf-crop:
    b. What is the predominant breed of the dams?
    c. Percent of Wagyu-influenced calves:

5.) Do you utilize a spring, fall, or both calving season? Please skip if this does not apply.
    a. Spring
    b. Fall
    c. Both
        i. If both, what is the percentage split?

6.) How many Wangus bulls or semen straws do you purchase from [redacted] (per year)?
    a. Number of bulls:
    b. Number of semen straws:

7.) Do you experience additional costs per head for Wangus or Wagyu-influenced cattle? If so, please describe.

8.) What production stages do Wagyu-influenced cattle move through on your ranch? (stocker, feedlot, retain ownership program, packer)

9.) Do you sell cattle back to [redacted]? What percentage of Wagyu-influenced cattle are sold back to [redacted]?

10.) What are your motivations for purchasing Wagyu-influenced genetics?

11.) What specific quality attributes about Wagyu-influenced cattle are attractive to your business?

12.) Have you received price premiums from selling Wagyu-influenced cattle? If so, what dollar amount higher per hundred weight ($/cwt) or per head ($/hd) than the other cattle you sell?

13.) How do you market the Wagyu-influenced cattle you have been producing from [redacted]'s genetics?

14.) What do you perceive about these cattle that add value to your customers?

15.) How has this relationship with [redacted] impacted your operation?

# APPENDIX B: Survey Questions – Fed Cattle Buyers

Survey Questions – Specialty Feedlot and Buyer Relationships

**Feedlot Buyers**

- Purchasing

1.) Approximately how many head of Wangus cattle do you purchase from [redacted] each year?
    a. What is the average lot size of your procurement?
    b. Describe the timing of these purchases (annually, semi-annually, monthly, etc.) How often do you purchase from them in a year?

2.) What percent of your total procurements are from [redacted]?
    a. What is the average lot size of your procurement?
    b. Describe the timing of these purchases (annually, semi-annually, monthly, etc.) How often do you purchase from them in a year?
    c. How many other sources do you have for Wangus cattle?

3.) How did you become aware of [redacted]'s operation?

4.) Describe the general business relationship you have with [redacted].

5.) Do you pay on a per hundred weight basis ($/cwt) or on a per head basis ($/hd)?
    a. On average how much more do you pay for Wangus calves versus other cattle procurements?

- Harvesting

6.) Do you contract with a packer or do you custom slaughter yourself after purchasing Wangus cattle?
    a. Please describe why.
    b. If you contract with a packer, describe the nature of the business relationship and how this affects your operation.

- Marketing

7.) What do you perceive about these cattle that add value to your customers?

8.) What are your motivations for purchasing Wagyu-influenced cattle?

9.) What specific quality attributes about Wangus cattle/beef are attractive to your business?

10.) How do you market Wangus beef? (Wagyu-influenced, high-quality, etc.)
    a. Is it marketed based on carcass characteristics, branded, or both?
    b. If branded, is it marketed as Wagyu or Wagyu-influenced?

11.) Is Wangus beef in a portfolio of products? Or is Wangus beef your entire portfolio?
    a. Briefly describe your portfolio of products.

12.) Does the beef you sell from Wangus cattle command a premium versus other beef products?

a. If so, how much more dollars per pound ($/lb)

13.) How has this relationship with [redacted] impacted your operation?

APPENDIX C: OSU IRB Exempt Approval Letter

**Oklahoma State University Institutional Review Board**

| | |
|---|---|
| Date: | 09/09/2022 |
| Application Number: | IRB-22-357 |
| Proposal Title: | Qualitative Analysis of Specialized Supply Chain Relationships in Wagyu-Influenced Beef |
| Principal Investigator: | Grace Baxter |
| Co-Investigator(s): | Kellie Raper |
| Faculty Adviser: | Kellie Raper |
| Project Coordinator: | |
| Research Assistant(s): | |
| Processed as: | Exempt |
| Exempt Category: | |

**Status Recommended by Reviewer(s): Approved**

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in 45CFR46.

**This study meets criteria in the Revised Common Rule, as well as, one or more of the circumstances for which continuing review is not required. As Principal Investigator of this research, you will be required to submit a status report to the IRB triennially.**

The final versions of any recruitment, consent and assent documents bearing the IRB approval stamp are available for download from IRBManager. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be approved by the IRB. Protocol modifications requiring approval may include changes to the title, PI, adviser, other research personnel, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any unanticipated and/or adverse events to the IRB Office promptly.
4. Notify the IRB office when your research project is complete or when you are no longer affiliated with Oklahoma State University.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact the IRB Office at 405-744-3377 or irb@okstate.edu.

Sincerely,

Oklahoma State University IRB

VITA

Grace A. Baxter

Candidate for the Degree of

Master of Science

Thesis: TARGETING PRIME: EXAMINING THE ECONOMIC ELEMENTS BEHIND WAGYU-INFLUENCED CATTLE

Major Field: Agricultural Economics

Biographical:

Education:

Completed the requirements for the Master of Science in Agricultural Economics at Oklahoma State University, Stillwater, Oklahoma in May, 2023.

Completed the requirements for the Bachelor of Science in Animal Science at Texas Tech University, Lubbock, Texas in May, 2021.

Experience:

Graduate Research Assistant – Oklahoma State University – Department of Agricultural Economics, Stillwater, Oklahoma

Graduate Teaching Assistant – Oklahoma State University – Department of Agricultural Economics, Stillwater, Oklahoma

Professional Memberships:

Food Distribution Research Society

Southern Agricultural Economics Association

Western Agricultural Economics Association