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Are Cattle Genetics Priced to Reflect Carcass Value?

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The impact of breed on carcass characteristics in various breeds of cattle has been well documented. This paper attaches these differences in breed characteristics to end revenue via different breed and breed combinations, percentage of Angus in pedigree, and purebred status. We find that while the genetics of many breeds is priced roughly in line with its value, some breeds are overpriced or underpriced by enough to significantly improve a cattle operation's profitability. We find that, relative to a pure Angus base, most breeds are less profitable in terms of carcass revenue per hundredweight.

Key words: cattle prices, farm management, herd improvement

Introduction

February 2019 saw a new world record price for a bull, with an Angus bull named SAV America selling for U.S.$1.51 million, nearly double the previous record of $800,000 in 2018. With bull prices like this and the beef stud industry charging as much as $100 per single dose, or straw, of semen,[1] the dollar value of the beef cattle genetics market is quite large (Bechtel, 2019). Cattle producers buy bulls or genetic material for artificial insemination hoping the investment in better genetics for their herds pays off in the form of higher profits from the sale of market steers and heifers. For example, if a farmer wished to improve the amount of muscle on their animals, they might use a Charolais dam because Charolais are known for their aptitude for muscle growth; if a farmer wanted to increase the marbling in their herd, she might use an Angus bull, a breed known for its superior marbling ability; or a farmer located in a warm climate might breed Brahman into their herd to introduce the breed's heat-resistant qualities.

In addition to genetics being tied to performance, the Angus breed has been the American beef industry standard for many years, mainly due to the view of many in the industry that Angus cattle have the best combination of meat quality and yield. Farmers expect to receive a larger premium the more cattle look like the accepted "standard" Angus cattle and can even receive a price deduction if they stray too far from the norm. The American Angus Association, the Angus breed association in the United States, has made extensive use of their branding ability with the Certified Angus Beef (CAB) label, and Angus has become one of the most recognized beef breeds in the country.

This is not to say other breeds are not as good as the Angus; in fact, some routinely out-perform the Angus, but only in specific areas and to the detriment of others (Field and Taylor, 2016). The breeds mentioned above are examples. This desire for an Angus look-alike—but with other breeds'

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[1] While this seems inconsequential in comparison to the price of a bull, it may take multiple doses of semen (called straws since they resemble drinking straws) for an animal to become pregnant due to human error or poor luck. Straws are also often bought in bulk quantities for an entire herd.

strengths in specific traits—has created a selective breeding process in the industry. This breeding process has even led some breeds to gradually shift hide color or average frame size to match the Angus look while attempting to retain the original breed's other beneficial traits.

The beef cattle industry clearly believes genetics to be important, which can have economic consequences for the profitability of a beef cattle operation. The question addressed here whether market prices for cattle genetics match the market value of the traits conveyed through those genetics. After decades of selective breeding, what is the measurable current difference between breeds in terms of profit at slaughter, if there is one? After all, the goal of a farmer should be to maximize profit, which, in a mixed-breed herd, should mean choosing to breed in more of the traits that maximize net revenue per animal. With the industry movement to grid pricing in the last 20 years, it is important to confirm whether the current methods of selective breeding translate to maximal profits.

Thus, the research question could also be stated as, "What is the relative marginal revenue of cattle genetics?" To answer this question, we seek to estimate the expected revenue per head for beef cattle of different breeds. If the expected revenue of, for example, a 100% Certified Black Angus is not higher than the average cattle breed's expected revenue by the additional cost of those genetics, a different breed would be more profitable.

Background

Animal science research into traits and benefits of different cattle breeds goes back to Koch et al. (1963), who investigated feed efficiency and how that trait is passed on to future generations. They found that 38% of the variation in animals' weight gain was due to differences in feed efficiency genetics, proving the importance and heritability of traits and motivating the selective breeding programs mentioned previously. Selective breeding programs led to an interest in breed compatibility or incompatibility. This comparison and the crossbreeding of different breeds led to several common hybrid types of cattle,[2] such as the Angus–Herford cross, commonly called a Black Baldy, or the Angus–Brahman, called a Brangus. Researchers continued to look at breeds and production differences as seen in (see Peacock et al., 1982; Koch et al., 1983; Bailey et al., 1982).

Ladd and Gibson (1978) looked into the cost of genetic improvement as it pertains to market hogs and took the first steps toward incorporating economics into research that had focused exclusively on animal science; their attempt to quantify the worth of new breeds or genes to a herd via an interdisciplinary team was notable, particularly for its time. Other research has investigated the link between cattle breeds and production traits (Marshall, 1994; Gregory et al., 1994; Gregory, Cundiff, and Koch, 1995), the demand for cattle production traits by farmers (Sy et al., 1997; Jabbar and Diedhiou, 2003; Ruto, Garrod, and Scarpa, 2007), and the role of genetic improvement in increasing productivity (Marsh, 1999).

The cattle industry now uses grid pricing to calculate the price per hundredweight (cwt) for animals at slaughter, with per pound pricing impacted by numerical scores for both quality and yield. Quality grade is a measure of the quality of the meat an animal produces and is mostly affected by fat deposition in the meat, called marbling. Yield grade is a measure of the amount of meat an animal produces and is affected by muscle size, frame size, and final weight. A pricing grid (see example in Figure 1) shows a price for every combination of yield and quality grades and the associated premium or discount relative to the base price in the middle of the grid, which is updated regularly by the USDA. Farmers can earn premiums (discounts), which are additive, for both quality and quantity increases (decreases) relative to the base norm, with prices across the grid varying by up to $25/cwt. Knowing which breeds are better at producing revenue at slaughter could be the difference between making and losing money.

[2] These crosses are generally F1 crosses.

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LM_CT169
St. Joseph, MO    Mon Feb 05, 2018    USDA Market News Service

5-AREA WEEKLY WTD AVERAGE DIRECT SLAUGHTER CATTLE - PREMIUMS AND DISCOUNTS
For the Week of:  2/5/2018
Value Adjustments
                                   Range        Wtd Avg    Change
Quality:
Prime                         10.00 -  22.00    17.29      0.00
Choice                         0.00 -   0.00     0.00      0.00
Select                       (10.00)-  (5.00)   (6.20)     0.03
Standard                     (40.00)- (12.00)  (19.13)     0.04
CAB                            3.00 -   5.00     4.03      0.28
All Natural                   22.00 -  28.00    23.92      0.00
NHTC                          16.00 -  22.00    19.31      0.00
Dairy - Type                 (14.00)-   0.00    (4.12)     0.00
Bullock/Stag                 (55.00)- (25.00)  (40.93)     0.00
Hardbone                     (55.00)- (20.00)  (33.66)     0.03
Dark Cutter                  (55.00)- (25.00)  (36.77)     0.03
Over 30 Months of Age        (40.00)- (10.00)  (16.36)     0.03

*Cutability Yield Grade, Fat/Inches
1.0-2.0 < .10"                 4.00 -   8.00     5.71      0.00
2.0-2.5 < .20"                 2.00 -   5.00     3.03      0.00
2.5-3.0 < .40"                 0.00 -   5.00     2.93      0.00
3.0-3.5 < .60"                 0.00 -   0.00     0.00      0.00
3.5-4.0 < .80"                 0.00 -   0.00     0.00      0.00
4.0-5.0 < 1.2"               (12.00)-  (8.00)   (9.77)     0.00
5.0/up > 1.2"                (20.00)- (10.00)  (14.80)     0.00

Weight:
400-500 lbs                  (40.00)- (15.00)  (25.78)     0.00
500-550 lbs                  (40.00)- (12.00)  (23.12)     0.00
550-600 lbs                  (15.00)-   0.00    (2.80)     0.00
600-900 lbs                    0.00 -   0.00     0.00      0.00
900-1000 lbs                 (15.00)-   0.00    (0.19)     0.00
1000-1050 lbs                (15.00)-   0.00    (2.36)     0.00
over 1050 lbs                (35.00)- (10.00)  (22.70)     0.00
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Figure 1. Example of the USDA Premium and Discount Weekly Changes

Source: https://www.ams.usda.gov/mnreports/lm_ct155.txt.

Quality grades	Yield grade 1	2	3 ($/cwt carcass)	4	5
Prime	8.00	7.00	6.00	-9.00	-14.00
CAB	3.00	2.00	1.00	N.A.	N.A.
Choice	2.00	1.00	**Base**	-15.00	-20.00
Select	-7.00	-8.00	-9.00	-24.00	-29.00
Standard	-16.00	-17.00	-18.00	-33.00	-38.00
CARCASS WEIGHTS			OTHER		
550-900 lb		Base (105.00)	Dark Cutter, etc. Bullock/Stags		-25.00 -25.00
Less than 550 lb		-19.00			
More than 900 lb		-19.00			

Figure 2. Example of a Pricing Grid Used to Calculate Prices per Hundredweight

Source: http://agrilife.org/agecoext/files/2013/10/rm1-11.pdf.

A number of papers have included a small set of breed indicators (such as Angus or Hereford) or hide color (sometimes simply a binary indicator for black as a proxy for Angus) in broader models of the determinants of cattle prices (see Parcell, Schroeder, and Hiner, 1995; Williams et al., 2012; Blank, Saitone, and Sexton, 2016; Mitchell, Peel, and Brorsen, 2018). Unlike the current paper—with designations for 17 different sire and 34 dam breeds—these studies focused more on production practices than on breed. Weaber and Lusk (2010) examined the impact that selected breeding of one trait, meat tenderness, can have on improvement in that trait as well as the associated benefit from the improvement. However, they do not model the trade-offs in selecting for that one trait over other attributes on which carcass pricing is based. Atsbeha, Kristofersson, and Rickertsen (2012) also examined the impact of a breeding program that only used the top 10% of animals as breeders, although they worked with dairy rather than beef cattle. This difference may explain why they did not consider the breed bundling of traits as much, since U.S. dairy herds are predominantly one of two breeds. Finally, McDonald and Schroeder (2003) examined the profit per head for fed cattle marketed using a grid structure. Though the base price and market price for feeder calves were the primary determinants of profitability, cattle quality was the most important nonprice factor affecting profitability.

Thus, this paper seeks to investigate the value of breed genetics in American cattle herds under the modern grid pricing system. We do this utilizing data on beef cattle enrolled in a herd management program in Georgia that is unusual in that the owners retained ownership when the cattle were sent to the feedlot, allowing us to obtain data on dam and sire genetics, production practices, and the eventual grading and pricing at slaughter.[3] With these data, a variety of regressions allow us to estimate the value of different breed genetics while controlling for production practices. These values can then be compared to the cost of different genetics to determine differences in net returns across breeds within this herd management program.[4]

Data

The data used in this paper are taken from the Georgia Beef Challenge from 2010 to 2016. The Georgia Beef Challenge is a retained-ownership program run by the Georgia Beef Extension Team in conjunction with Tri-County Steer Carcass Futurity Co-Operative (TCSCF) of Lewis, Iowa. Calves enrolled in the program are required to follow a predetermined health maintenance protocol while at the farm, are all shipped to the same feedlot in Iowa, fed by the TCSCF, and then sent to the same processing facility to limit unobservable variability in production and processing.

The data from the Georgia Beef Challenge are unique because they allow for comparison of animals from different farms all the way to end production, which would normally require farm-level production data on the kind and amount of feed, housing, vaccines, and medical procedures the animals received as well as data on differences in auction houses, feedlots, and processing facilities, all kept for individual animals. This dataset, however, comes from a program that requires farmers to adhere to specific production protocols while the calves are on the farm and then sends animals to the same feedlot and on to the same processing facility. This eliminates much of the immeasurable variability in production and allows us to examine the effect of breeds and genetics, the only major uncontrolled variable with significant effects on the production and carcass traits of the calves other than easily measurable traits such as sex, age, and breed. Any uncontrolled farm-level variation is assumed to be independent of farmers' choices of breeds.

Body weights are collected when animals leave the farm, when they arrive at the feedlot in Iowa, and when slaughtered. Other carcass trait data collected at processing for each animal include REA,[5] %KPH,[6] percentage fat cover, marbling, and yield grade. Production traits such at overall average

[3] As a reviewer helpfully pointed out, we assume that the production costs are equal across all breeds, including such aspects as animal health, when we eventually compare the marginal revenue of a breed to its genetic cost. This is probably truer than usual here given that our data come from herds managed in a very prescribed way, but factoring in such cost side benefits of different breeds would be useful follow-on research.

[4] Zohrabian et al. (2003) found an imbalance in the plant genetics market for middle products in the germplasm industry that would be unsustainable in the long term. This partly inspired our search for mispricing in the market for cattle genetics.

[5] REA is the ribeye area, which is the total area of the ribeye at the 12th and 13th rib in square inches. This is used to help calculate the yield grade.

[6] %KPH is the abbreviation for kidney, pelvis, and heart fat, which measures the percentage of body fat found in the body cavity of the carcass. It is normally 1%–4% and is used to calculate the yield grade.

Table 1. Summary of Controls

	Mean	Std. Dev.	Min.	Max.
Sex	0.74	0.44	–	1
Days of age	482.13	71.62	271	925
Final weight	1,209.36	1,212.62	767	1,677
Days on feed	155.49	19.10	95	203

daily gain (ADG)[7] and physical traits such as sex and days of age (DOA) were also collected. During data cleaning, observations that were missing values for variables used in regressions were excluded. Data were not manipulated other than to create numerical indicators for the breed names, year, level of Angus in pedigree, and mix or purebred status to assist analysis. These are discussed in more detail below.

As mentioned above, the raw data were used to create additional variables for a variety of measures, including total days on feed and the month in which the animal was processed, to capture seasonal variation in base price, which is not tied to breed. Indicator variables were also created for the different combinations of sire and dam for each sire and dam breed separately and every combination of the 17 sire breed types and 34 dam breed types present in the dataset. A variable was created for the percentage of Angus in an animal's pedigree, dividing animals into five categories, starting at 100% Angus (all four grandparents were Angus) and decreasing by quarters to 0% Angus (no Angus for two generations). This allowed us to compare the impact of the level of Angus genetics on revenues. To assess the claim of possible improvements due to hybrid vigor, we also created a dummy variable to compare the difference in impact of purebred animals, regardless of breed, relative to F1 or F2 crosses.

Some additional variables were created to account for shifts in the overall cattle market, which was particularly volatile during the period of data collection. A series of dummy variables to account for every year included in the dataset, as well as the month variables mentioned earlier to account for cyclical changes in the cattle market, are used to capture price volatility in the market during the period of data collection. Table 1 reports some summary statistics on nonbreed control variables.

Last, we note that our data are not a random or representative sample. The sample is not balanced by breed; rather, there is a significant skew toward Angus and Angus-composite breeds. Selection into the program by farmers—as well as the specific animals they chose to enroll in the program—may also be skewed (toward the best, newest, or most inclined to experiment operators). However, if any sample selection bias is relatively constant among the enrollees, this should not particularly affect our results since we are looking to estimate relative differences between breeds, not the absolute value of cattle genetics.

Methods

We use hedonic pricing models to estimate the marginal value of different cattle genetics by breed. Hedonic models, which date from Lancaster (1966), assign the value of a good or service to individual components used to fashion the product. In our context, that means we use linear regression models to estimate the impact on the carcass price per hundredweight of cattle in our data on a large set of characteristics of those cattle, including their breeds. Table 2 provides breed abbreviations for clarity of reading.

[7] Average daily gain is the animal's total weight divided by their age in days.

Table 2. Breed Abbreviation Key

Abbreviation	Breed
AN	Angus
AR	Red Angus
BN	Brangus
CH	Charlois
HE	Hereford
LM	Limosin
SM	Simmintal
XX	Commercial
BO	Braford
BR	Brahmin
GV	Gelbvieh
SG	Sainta Gertudis
RB	Red Brangus

These models take the following form, dropping observation subscripts for simplicity:

$$\begin{aligned}\text{Carcass price per cwt} = {} & \alpha_0 + \alpha_1 age + \alpha_2 sex + \alpha_3 \textit{final live weight} + \alpha_4 \textit{final weight}^2 \\ & + \alpha_5 \textit{days on feed} + \alpha_6 \textit{days on feed}^2 \\ & + \alpha_7 \textit{days on feed} \times \textit{final live weight} + \sum_1^6 \alpha_k YD + \sum_1^{10} \alpha_j MD \\ & + \sum_{i=1}^{n} \alpha_i BD + \varepsilon. \end{aligned} \tag{1}$$

To examine the value of cattle genetics, we estimate several models in the form of equation (1), holding the set of other control variables constant as shown above but using different sets of breed variables. The breed variables represented by the set of BD will include sire breed, dam breed, percentage Angus, or purebred. Additional variables are included to control other carcass variation. Final weight and final weight squared are included to capture the nonlinear effects of increasing weight, which at first has a beneficial effect on revenues but then a detrimental one after some point. The interaction of final weight and days on feed is included to account for the significant drop in cattle inventory in the United States during the data collection period, which caused animals to be kept in the feed lots for longer than the optimal time frame rather than have empty feedlots, thus resulting in larger animals at slaughter.[8] Days on feed and days on feed squared were included to capture the hypothesized inverted-U-shaped impact of the length of time spent in the feedlot. Annual and monthly time variables are used to account for the upward shift in cattle prices around 2014 and then the following plummet in 2015 as well as seasonal variation in cattle prices throughout the year, and are represented by YD and MD, respectively. Other possible independent variables, such as average daily gain, were not included since they either are greatly affected by the breed of an animal or the components to calculate them are already included in the above-mentioned variables. An error term, ε, serves to capture remaining, unmodeled variation.

Empirical Results

The results of the regressions on revenue prove interesting on several fronts. From an economic point of view, the market for beef genetics appears to be efficient for the most part, with a few exceptions.

[8] This drop in feeder cattle limited feed lot operators to the choice of having empty feed lots or keeping the cattle they had on hand longer than optimal and feeding them out to a higher weight and trying to capture some lost revenue there.

Table 3. Results from the Regression of Sire Breeds on Final Carcass Price

	Parameter Values	Std. Dev.	*N*
Sire ANHE	−2.155	5.226	5
Sire ANSM	−3.361	8.230	2
Sire ANXX	−1.170	2.643	20
Sire ARAR	−6.757***	1.448	80
Sire ARSM	−3.926	8.227	2
Sire BNBN	−4.737	8.243	2
Sire CHCH	−3.134*	1.685	51
Sire HEHE	0.808	0.967	184
Sire LMLM	−3.644	6.706	3
Sire SMAN	−3.641***	0.880	212
Sire SMAR	−9.514***	2.399	25
Sire SMSM	−2.106**	0.917	199
Sire ANAR	−15.330***	5.880	4
Sire BOBO	5.151	3.857	10
Sire BRBR	12.377	11.623	1
Sire RBRB	10.695*	5.827	4

Notes: When presented together, the sire's breed will always come before the dam's. All breeds presented are comapared to a pure Angus base (ANAN). Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.

Table 3 shows that the relative value of 16 sire breeds relative to pure Angus (ANAN) is usually negative, implying that one expects to earn less in total carcass price for almost all breeds. This is expected given market participants' preference for Angus. Of the sires with positive coefficients—which includes purebred Herford (HEHE), purebred Braford (BOBO), purebred Brahman (BRBR), and purebred Red Brangus (RBRB)—only Red Brangus, which appears four times in this dataset, is statistically significant. It should also be noted, the sire breed with the most negative value relative to Angus is the Red Angus–Angus (ANAR) cross, appearing four times in the dataset.

When the independent variables of interest in the ordinary least squares (OLS) regressions are the breed of the animals' dam, the overall pattern for the relative value of different dams is also negative, meaning an expected total carcass price is lower than expected with a pure Angus (ANAN) dam used as the base of comparison. This would mean the market, at least in reference to dam breeds, also functions efficiently, with demand for genetics appearing mostly in line with the economic value produced by those genetics. There are only seven positive coefficients for relative value, and the only significant one is for the purebred Brangus (BNBN), matching the pattern of Brahman genetics being present in animals that outperform Angus in the sire regression. Another interesting result emerges in the form of the breed makeups of those dams with significant negative coefficients, meaning their offspring were worth less at slaughter than offspring with pure Angus dams. Of ten breeds with statistically significant negative relative values, five of them are some type of Angus cross. Table 4 presents the results for the dam variables.

When the regressions are run with both sire and dam breeds in the model, the results show the same basic results as above.[9] Of more than 100 breed combinations present in the sample, only 24 result in positive expected values relative to the Angus base breed. Of those 24 breeds, only three are statistically significant: the Charolais (CHCH)[10]–Brangus (BNBN) cross (appearing twice in the dataset), the Simmental (SMSM)–Angus-Commercial (ANXX) cross (appearing 45 times in the dataset), and the Red Brangus (RBRB)–Red Angus-Commercial (ARXX) (appearing three times in the dataset). All of the coefficients on these three breeds are large and would have a marked, economically significant impact on revenues. The types of breeds that were significant and positive

[9] Due to space constraints, these results are not reported but are available from the authors on request.

[10] Please note that sire breeds are always presented first (e.g., the Charolais–Brangus cross above has a Charolais sire and a Brangus dam).

Table 4. Results from the Regression of Dam Breeds on Final Carcass Price

	Parameter Values	Std. Dev.	*N*
Dam ANHE	−8.113***	2.565	20
Dam ANSM	−2.569	1.825	41
Dam ANXX	−3.313***	0.595	978
Dam ARAR	−12.767***	1.961	39
Dam ARSM	−11.686***	1.874	48
Dam BNBN	15.657**	6.571	3
Dam CHCH	−12.192**	5.684	4
Dam HEHE	−0.855	1.064	162
Dam LMLM	−7.142	4.626	6
Dam SMAN	−4.994***	1.184	116
Dam SMAR	−15.891	11.289	1
Dam SMSM	−12.083***	1.434	72
Dam ANBN	−21.285***	2.588	20
Dam ANCH	−14.614**	6.527	3
Dam ANGV	−2.050	3.808	9
Dam ANLM	2.804	7.997	2
Dam ARHE	−11.014	11.301	1
Dam ARXX	0.044	1.941	37
Dam BNSM	−6.082	6.583	3
Dam BNXX	−2.581	1.950	36
Dam BRXX	−1.181	5.113	5
Dam CHXX	1.394	2.421	23
Dam GVGV	−4.036	2.979	15
Dam GVHE	3.917	11.302	1
Dam GVXX	−12.538	11.297	1
Dam HEXX	−1.724	3.817	9
Dam LMAR	−6.810	11.317	1
Dam LMGV	−8.434	8.005	2
Dam LMXX	−0.760	11.313	1
Dam SGXX	5.120	6.541	3
Dam SMBN	−13.371***	5.071	5
Dam SMXX	−0.403	1.785	43
Dam XXXX	0.628	1.527	65

Notes: When presented together, the sire's breed will always come before the dam's. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.

are also interesting as they are all composites of at least three breeds,[11] which seems to increase support for crossbreeding but perhaps goes against the concept of the F1 generations being the most productive due to the highest levels of hybrid vigor. All breeds that outperform the Angus base also have at least some Angus in their pedigree. These results suggest that conventional wisdom on beef cattle genetics is mostly valid but not perfect.

In drawing conclusions from these breed comparisons, it should be noted that the dataset is not balanced evenly among all breeds and breed combinations. Of the 2,645 observations, the significantly positive results are, for the most part, for breeds with fewer than 10 observations each. This small sample size for the significant results may raise worries about sampling error; however, they are certainly worth further investigation.

We also estimated a regression in which final carcass weight is regressed on the percentage of Angus in an animal's pedigree, which produced some interesting results. The regression results

[11] Brangus animals, while their own breed, are a composite breed of a Brahman and an Angus.

Table 5. Results from the Regression of Angus Pedigree and Nix-Breed Status on Final Carcass Weight

	Parameter Values	Std. Dev.	*N*
0% Angus	-2.404^{***}	0.9234	231
25% Angus	-3.088^{***}	0.9513	198
50% Angus	-3.942^{***}	0.7343	415
75% Angus	-5.120^{***}	0.6171	963
Mix Breed	-3.799^{***}	0.5225	1,647

Notes: The first four rows are compared to a pure Angus base; the last column is compared to a purebred base. Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level.

still support the Angus dominance of the industry, as all coefficients on the variables of interest are negative compared to the pure Angus base, but most interesting is the comparison of the magnitude of the negativity for each category. These results imply the next best thing to having a 100% Angus animal would be to have an animal that is 25% or 0% Angus, as the confidence intervals for these two categories overlap (Table 5). The next best would be a 50% Angus animal; 75% Angus animals have the lowest expected carcass value, even below generic mixed breeds. This is opposite the expected outcome and again seems to lend more merit to having F2 generation animals so as to achieve the 25% Angus versus the highly touted F1.

Having discussed the main results of our models, let us turn briefly to the other variables used as controls in these regressions, as the coefficients on them can increase confidence in the empirical results if they are reasonable and well behaved. The same controls were used for all four of the regressions above, and the estimated coefficients on the control variables are similar in sign, magnitude, and significance; thus, they will be discussed together and are available in Table 6. The parameter on the sex variable shows that heifers have more value, by about \$3.50/cwt–\$4.00/cwt, than steers. This seems completely against the norm for the entire cattle industry; however, because the model also includes the final weight, the sex control picks up the quality difference between the two sexes since final weight is controlled for separately. If one is comparing two beef cattle of different sexes, *ceteris paribus*, the female will generally grade better quality-wise due to higher rates of fat deposition in muscle by the female animal, leading the female to earn a higher carcass value (Venkata Reddy et al., 2015). The dummies for years show the correct pattern of the extreme spike in cattle prices around 2014 and the subsequent decline in 2015. The monthly variables, indicating the month the animal was processed, show the typical seasonal changes in beef prices throughout the year, with the summer months (grilling season) having higher prices than winter months. July was used as the base month and September is not included as there are no data points with processing dates in that month. The resulting changes in feed lot behavior, mentioned above, are shown in the days on feed and days on feed squared parameters, which show the expected changes of an upward limit on the benefits to keeping an animal on the feed lot and then subsequent days in the feed lot resulting in a loss. The optimal days on feed that would maximize carcass value range from 250 to 325 days on feed over our different models. This calculation may seem high compared to the general practice, but feeding for 8–10 months would result in maximum slaughter weight, not maximum profit, since it does not consider the cost of keeping an animal on the feedlot for another day. The results shown in Table 6 are in keeping with theory and robust across the models, suggesting some support and added credibility for the main empirical results.

These results allow us to compare our estimated value of genetics to the cost of those same genetics in the marketplace. Since straws are only sold for sires, we compared current average straw prices of the different breeds obtained from three different suppliers to the predicted revenue gains by sire breed calculated from our sire model results in Table 3. We compared value added per

Table 6. Regression Results for Controls

Variable	Sire	Dam	Combination	Percentage Angus	Purebred
Gender	−1.470**	−1.884***	−2.094***	−1.500**	−1.516**
	(0.614)	(0.598)	(0.598)	(0.604)	(0.604)
Days of age	0.002	.008**	.010***	0.005	0.002
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)
Final weight	−0.104***	−0.102***	−0.089***	−0.100***	−0.106***
	(0.034)	(0.034)	(0.033)	(0.0343)	(0.034)
Final weight^2	−0.002***	< 0.001***	< 0.001**	< 0.001***	< 0.001***
	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
Days on feed	0.615***	0.646***	0.743***	0.802	0.756***
	(0.212)	(0.208)	(0.209)	(0.211)	(0.211)
Days on feed^2	−0.002***	−0.002***	−0.003***	−0.003	−0.003***
	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
Days on feed ×	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
final weight	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)	(< 0.001)
Year 1	−13.533	−11.233	−10.715	−9.539	−12.133
	(12.096)	(11.761)	(11.528)	(12.048)	(12.062)
Year 2	−12.887***	−12.188***	−12.627***	−11.788***	−11.901***
	(0.820)	(0.827)	(0.875)	(0.819)	(0.819)
Year 3	−17.242***	−16.556***	−17.357***	−15.906***	−16.060***
	(0.814)	(0.807)	(0.855)	(0.805)	(0.806)
Year 4	8.693***	9.663***	7.608***	8.722***	8.900***
	(0.921)	(0.896)	(0.939)	(0.905)	(0.906)
Year 5	−10.456**	−8.270*	−8.454*	−7.983*	−8.563*
	(4.625)	(4.534)	(4.564)	(4.597)	(4.601)
January	−12.785***	−11.843***	−13.400***	−13.863***	−14.215***
	(1.480)	(1.438)	(1.570)	(1.418)	(1.413)
February	−8.206***	−7.435***	−9.488***	−8.583***	−8.796***
	(1.313)	(1.258)	(1.395)	(1.249)	(1.250)
March	−7.378***	−6.622***	−8.431***	−7.245***	−7.367***
	(1.248)	(1.162)	(1.290)	(1.184)	(1.189)
Arpil	−11.569***	−10.983***	−13.283***	−12.205***	−11.997***
	(1.262)	(1.183)	(1.315)	(1.208)	(1.210)
May	−11.631***	−10.872***	−13.771***	−11.925***	−11.891***
	(1.390)	(1.302)	(1.424)	(1.327)	(1.330)
June	−13.492***	−12.524***	−14.865***	−11.692***	−11.934***
	(1.581)	(1.482)	(1.593)	(1.505)	(1.501)
August	−4.263	−2.248	−1.269	−7.963***	−7.663***
	(3.008)	(2.968)	(3.195)	(2.924)	(2.927)
November	−4.971	−7.589	−10.925	−11.095	−8.018
	(14.945)	(14.533)	(14.263)	(14.904)	(14.914)
December	−3.391	−2.919	−4.628	−4.177	−3.950
	(3.308)	(3.189)	(3.306)	(3.246)	(3.251)

Notes: Single, double, and triple asterisks (*, **, ***) indicate significance at the 10%, 5%, and 1% level. Numbers in parentheses are standard errors.

Table 7. Gains and Losses of Genetics Compared to Pure Angus Sires

Sire Breed	Difference at Yearling Weight	Difference at Slaughter Weight
Red Angus	−$32.10	−$65.89
Charlois	−$14.10	−$29.76
Sim-Angus	−$18.17	−$36.37
Sim-Red Angus	−$47.53	−$95.10
Simmintal	$0.39	−$10.14
Red/Black Angus	−$74.97	−$151.62
Braford	$72.42	$144.83
Brahman	$114.43	$235.94
Red Brahman	$53.48	$106.95

Notes: These breeds were both significant in the sire regression and present in the genetics data set. Red/Black Angus are sires with one red Angus parent and one black Angus parent. Genetics data were gathered from Select Sires, ABS, and Genex.

hundredweight at both a yearling feeder cattle weight and at an auction slaughter weight,[12] with the difference between the estimated value and the market cost of the genetics shown in Table 7.

With the value-added calculated out to the appropriate weights, there appears to be a potential underpricing of Brahman sire genetics of up to $114 if owned until a yearling feeder cattle or $236 for slaughter-weight animals[13] and an overpricing of $75 for yearling feeder cattle and $152 for slaughter-weight animals for Red Angus and Black Angus cross genetics.[14] The rest of the results for this comparison can be found in Table 7. These results show that many breed genetics are properly priced (e.g., Simmental), some are quite close to our estimated values (e.g., Charolais), many are somewhat overpriced (e.g., Sim–Angus, Red/Black Angus), and a few breeds appear to be underpriced by economically significant amounts, perhaps due to misperceptions among cattle owners over the true market value of genetic influences on cattle characteristics. A cattle owner taking this paper to heart would start buying Braford, Brahman, and Red Brahman genetics to take advantage of this observed genetics pricing inefficiency. Of course, these results may apply more to warm climate cow–calf producing regions such as Georgia and Texas than to colder, northern production areas.

Conclusions

This paper contains several important insights, each with its own set of implications for the beef industry. The first and main insight is that breed can affect carcass value on the order of $10/cwt ($100/head) difference to the revenue of the farmer in a retained-ownership program. The second insight is the validation of the Angus breed as the standard for performance in the beef cattle industry, due to their combination of both quality and quantity relative to other breeds. This strengthens the position of groups like the Angus Breed Association to campaign for even more benefits for their members. It also could lead more farmers to breed their herds to be more like Angus to capture potential increases in revenue up to or over $240/head in extreme cases.[15]

This proof of breed differences also decreases concern for the idea of gradual breed drift in other breeds to be more like Angus, unless the breed drift is incredibly slow. The main concern of breed drift is the loss of genetic diversity within beef cattle and the ability of the species to withstand

[12] These values were calculated using the per hundredweight value multiplied by an average animal weight at these timeframes (i.e., 5 cwt and 10 cwt, respectively). These milestones were chosen due to the high frequency of animals being sold at these times in their lives. Is it also assumed that the value is evenly spread over all hundredweight.

[13] Again, this may be due to the unbalanced nature of the dataset.

[14] This is possibly due to the fact that—given the way in which hide colors are passed on genetically—it is possible to lose track of the red hide color gene because it is dominated by the black color gene and could pop up unexpectedly in later generations.

[15] This number was taken from the regressions results (which are given in a per hundredweight measure) and multiplying them by the animal's weight (in cwt).

potential catastrophic illnesses. Farmers have gone through about 30 generations of cattle from the time Koch et al. (1963) started the formal literature on breed benefits in beef cattle. These results suggest that genetic drift is not a concern. If it were, the economic value advantage of the Angus breed would be smaller than estimated here.

If the drift is, in fact, slow enough that the differences in breeds persist as shown, it somewhat calls into question the validity of selective breeding programs, at least those that select within breeds. If a breed cannot be directed in a new direction within a short enough time span to make a difference, what is the use of selective breeding programs? Determining which of these two cases is true, however, would require a longer-term study of same-breed animals.

A finding, rather unexpected, was the Brahman breed's frequent appearance in the breed composites that outperform Angus. While the Brahman's main claim is to increase hardiness in hot, pest-prone climates, which would have been washed out of the results via the controls, they are not well known for having good quality or extraordinary yield. It is unclear at present what particular factor is helping animals with some degree of Brahman genetics perform better than Angus, but the result is worth investigating as it suggests economic gains could be made by exploiting an inefficiency in cattle genetic pricing.

The carcass value models strengthen this surprising result that animals made up of three breeds did better than the pure Angus base breed type. These animals are probably the same as those included in the 25% Angus group since all breeds have at least some Angus in their background. This finding could really change the way breeding programs operate in the future. If the animals that earn the most are composites of three breeds, many more cow–calf operations should begin to invest in crossbred instead of purebred cows so they can produce three-breed composite calves. Stud farms as well could start offering crossbred studs for the same reason, though we think this is the less likely of the two options.

Finally, our empirical results suggest some limited mispricing exists in the markets for cattle genetics, specifically underpricing of Brahman and Braford genetics. Cattle producers would be wise to take advantage of these market imperfections as the predicted gains (of perhaps $100/calf) are large enough to turn a money-losing cow–calf operation into a profitable one.

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