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An Economic Analysis of Genetic Information: Leptin Genotyping in Fed Cattle

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A polymorphism in the leptin gene is associated with fat deposition. Since fed cattle are often priced on a grid that considers yield and quality grades, fat deposition is an important factor in profitability. Using data from 590 crossbred steers and heifers, we simulate carcass traits to various days-on-feed and compute the associated profit under three price grids. Results indicate that leptin genotype does affect value by as much as \$48 per head but has little impact on days-on-feed. Given current commercial testing fees of \$40–\$50 per sample, genotyping of feeder cattle appears to break even at best.

Key words: beef cattle, genetics, leptin genotype, value of information

Introduction

The deposition of fat in fed cattle has a large role in beef carcass value and producer profits. An improved understanding of how and where fat is deposited, externally versus intramuscularly, has the potential to improve decisions of feedlot operators. Polymorphisms, or mutations, in the leptin gene have been shown to influence fat deposition in fed beef cattle (Bierman et al., 2004; Buchanan et al., 2002; Kononoff et al., 2005; Larson et al., 2005, 2006). The leptin gene has been marketed in the past as a “marbling gene,” but biological research shows that both backfat and marbling are affected by leptin genotype. As the market rewards marbling but discounts external carcass fat, leptin genotype has offsetting economic impacts for producers. The net economic impact is unknown. Further, it is not known if genotype affects optimal days-on-feed. Our goals are to determine if leptin genotype: (a) affects optimal days-on-feed, and (b) affects carcass value. In short, can a producer utilize leptin genotypic information to increase profitability?

Assuming profit-maximizing behavior, we determine the optimal marketing date for fed cattle sold: (a) individually, and (b) in truckload groups (about 45 head). Optimal days-on-feed are determined both with and without leptin genotypic information. We first develop a regression model of economically relevant carcass traits (external carcass

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fat, ribeye area, hot carcass weight, and marbling score) using measurements taken during the finishing period and post-slaughter. The regression model is evaluated twice, with and without leptin genotypic information. Second, we simulate carcass characteristics for various days-on-feed for each individual animal and determine profits associated with each day on feed for each animal. Third, we determine the optimal days-on-feed and maximum profits for each animal, with and without genotypic information, for three different price grids. Finally, the differences in maximum profits are used to assess the ex ante value of leptin genotypic information.

Economics of Days-on-Feed and Fat in Fed Cattle

Producers are assumed to maximize the sum of profits over all cattle fed, or:

$$(1) \quad \max_{DOF_i} \sum_i \pi_i(DOF_i) = \sum_i \left[P_B + P_{YG}(REA_i(DOF_i), HCW_i(DOF_i), BF_i(DOF_i), KPH_i(DOF_i)) + P_{QG}(MS(DOF_i)) \right] \times HCW_i(DOF_i) - IC_i - C(DOF_i) - OC(DOF_i),$$

where DOF_i denotes days-on-feed for animal i . Profit from a finished animal is equal to the revenue less the purchase price of the calf (IC), total daily feed and yardage costs (C), and opportunity cost (OC). Revenue is a function of price (per lb.) and weight. Both price and weight are a function of days of feed.

The price received for an animal is derived from a base price P_B and discounts/premiums for yield grade (P_{YG}) and quality grade (P_{QG}). Premiums and discounts for yield and quality grade are paid based upon carcass characteristics, which in turn are functions of DOF . Yield grade (YG) is determined from ribeye area (REA), hot carcass weight (HCW), backfat (BF), and percentage kidney, pelvic, and heart fat (KPH).

Yield grade, which along with market conditions determines P_{YG} , is written as:

$$(2) \quad YG_{ik} = 2.5 + 2.5 \times BF_{ik} + 0.2 \times KPH_{ik} + 0.0038 \times HCW_{ik} - 0.32 \times REA_{ik}$$

[U.S. Department of Agriculture/Agricultural Marketing Service (USDA/AMS), 1997]. The scores given by (2) are truncated so that only integer values (1–5) are used to determine yield grade premiums. As days-on-feed increase, BF , KPH , HCW , and REA increase. The increased BF , KPH , and HCW lead to increased yield grades, whereas the increased REA leads to lower yield grades. Yield grades 4 and 5 are discounted by the market, while yield grades 1 and 2 earn premiums. So, DOF has offsetting effects on P_{YG} .

Quality grade is determined by a subjective marbling score. Marbling score, which along with market conditions determines P_{QG} , is based on a subjective scale (USDA/AMS, 1997). *Traces* of intramuscular fat are scored between 200 and 299 and called Standard. Scores between 300–399 or *slight* marbling are Select, from 400–499 or *small* marbling are called low Choice, from 500–599 or *modest* marbling are average Choice, from 600–699 or *moderate* marbling are high Choice, and scores over 700 are Prime. Quality grades of average Choice and higher earn premiums while quality grades Select and Standard are discounted. Increasing DOF leads to higher marbling scores and higher premiums or lower discounts.

In addition to affecting revenue, a change in days-on-feed will affect costs. There are three daily costs during the finishing phase: feed, yardage, and opportunity cost on investment. Marginal feed and yardage costs are constant, and opportunity cost will increase at an increasing rate with *DOF*.

Leptin Biology and Economic Relevance

Leptin is a protein hormone produced by fat. It is released into the blood and transported to the brain. The brain then determines the amount of energy the body will expend (Rodriguez et al., 2002) versus the amount of energy stored as fat. A mutation, or polymorphism, in the leptin gene has been linked to variation in carcass composition (Buchanan et al., 2002; Geary et al., 2003; Yamada, Kawakami, and Nakanishi, 2003). The polymorphism is a nucleotide switch from cytosine (*C*) to thymine (*T*) and causes an amino acid change in the circulating leptin. An animal can have one of three possible genotypes: *CC* (homozygous “lean”), *CT* (heterozygous), and *TT* (homozygous “fat”). Between genotypes, significant differences have been observed for both 12th rib fat and marbling score (Buchanan et al., 2002). Fatter carcasses have been associated with the *T*-allele, while the *C*-allele has been associated with leaner carcasses (Kemp, 2003; Thue et al., 2001). Kemp also noted that the animals with two copies of the *T*-allele deposited 12th rib fat earlier in the finishing process and at lighter weights. Several other studies (Bierman et al., 2004; Bierman and Marshall, 2001; Buchanan et al., 2002; Fitzsimmons et al., 1998; Oprzadek et al., 2003; Tessanne, Hines, and Davis, 2003; Thue et al., 2001) reported a relationship between leptin gene polymorphisms and fat deposition in beef carcasses.

Certain breeds of cattle (e.g., Hereford and Angus) are often associated with higher fat levels (Fitzsimmons et al., 1998). Fitzsimmons et al. found that these “fat” breeds had the greatest frequency of the “fat” (*T*) allele. Similarly, they noted that breeds generally accepted as “lean” breeds (e.g., Charolais and Simmental) possessed a greater frequency of the “lean” (*C*) allele.

Because of leptin’s relationship to fat, leptin genotype is hypothesized to affect yield and grades. Since *TT* cattle deposit fat more quickly than *CT* or *CC* cattle, *TT* cattle are expected to have more discounts for yield grades 4 and 5 and fewer premiums for yield grades 1 and 2. Conversely, *CC* cattle, being leaner, should earn more yield grade premiums and fewer discounts. It is also anticipated that *TT* cattle will have higher marbling scores and more quality grade premiums (or fewer discounts). The leaner *CC* cattle are expected to earn more discounts for quality grade.

In summary, leptin genotype affects fat deposition and so affects yield and quality grades. It seems likely that *TT* cattle will earn more premiums for high quality grades but also have more discounts for high yield grades. As *CC* cattle are leaner, it is expected that they will earn fewer premiums and more discounts for quality grade while earning more premiums for yield grade. For both lean (*CC*) and fat (*TT*) genotype, there are offsetting biological and economic effects.

Biological Model and Data

Our modeling efforts are divided into two parts, a biological model and an economic model. The variables used in these models and their definitions are presented in table 1.

Table 1. Definitions of Variables Used in the Models

Variable	Definition
i	Subscript indicating animal identification, $i \in \{1, \dots, 590\}$
j	Subscript indicating measurement date
k	Subscript indicating marketing date, $k \in \{160, \dots, 220\}$
BF_{ij}	12th rib fat for the i th calf on the j th date
REA_{ij}	Ribeye area for the i th calf on the j th date
W_{ij}	Weight for the i th calf on the j th date
HCW_{ik}	Hot carcass weight for the i th calf on the k th marketing date
MS_{ik}	Marbling score for the i th calf on the k th marketing date
KPH_{ik}	Percent kidney, pelvic, and heart fat for the i th calf on the k th marketing date
DOF_i	Days-on-feed for the i th calf
$source_i$	Dummy variable with 0 = purchased heifers and 1 = "home-raised" calves (steers and heifers)
$nrtreat$	Number of treatments for non-respiratory illness
$restreat$	Number of treatments for respiratory illness
YG_i	USDA yield grade on a scale of 1–5, where 1 = leanest carcasses and 5 = fattest carcasses
QG_i	USDA quality grade: Standard, Select, Choice, and Prime
P_B	Base carcass price (\$/cwt)
P_{YG}	Premium/discount (\$/cwt) for USDA yield grade
P_{GQ}	Premium/discount (\$/cwt) for USDA quality grade
$C(DOF_i)$	Cost as a function of days-on-feed
IC_i	Purchase cost of feeder calf i
$OC(DOF_i)$	Opportunity cost of investment

Since carcass revenues are derived, in part, from yield and quality grades and weight, it is necessary to develop a biological model to simulate the components of yield and quality—in particular, ribeye area, backfat, hot carcass weight, and marbling score. The biological model is estimated twice, with and without leptin genotypic knowledge.

Data were collected from cattle in a commercial feedlot in Britton, South Dakota, from fall 2004 through early summer 2005. At our request, the feedlot operator put together three pens (approximately 200 head per pen) of feeder cattle with similar breed and phenotype within each pen. Two of the pens were heifers and the other steers. Thus, the number of heifers is approximately double the number of steers. The pen of steers (lot 1) and one pen of heifers (lot 2) were born on the feedlot operator's farm and primarily are a black Angus cross. The other pen of heifers (lot 3) was purchased from ranches in Montana and primarily are red Angus/Simmental cross.

Weights, measurements, and blood samples were taken from 612 steers and heifers. After lost ear tags, missed tag transfers in the processing plant, and other carcasses "lost" in the processing plant, data on 590 cattle were usable. Data were collected on November 10, 2004; January 5, 2005; February 10, 2005; and March 28, 2005; and on the four marketing dates of April 19, May 5, May 18, and June 6, 2005. Live weights and ultrasound measurements of backfat were taken on all four pre-marketing dates. Ultrasound measurements of ribeye area were taken on the November and February dates. Additionally, the feedlot operator recorded all treatments due to non-respiratory and respiratory ailments for each animal. At slaughter, hot carcass weights were recorded.

Twenty-four hours post-slaughter, measurements were taken on ribeye area and backfat and subjective estimates of marbling score and percent kidney, pelvic, and heart fat were recorded. Summary statistics for initial weights and measurements and carcass weights and measurements are given in table 2. Table 2 also reports the number of steers and heifers by genotype.

On November 10, 2004, blood samples were taken via venopuncture. Leptin genotype was analyzed by an allelic discrimination assay. Briefly, genomic DNA was purified (Perfect gDNA, Eppendorf AG, Hamburg, Germany) and specifically designed probes were used to detect the *C/T* polymorphism (Primer Express, Applied Biosystems, Forest City, CA; Buchanan et al., 2002) using real-time PCR technology (Prism 7000, Applied Biosystems).

To allow for the simulation, we estimate final marbling score, ribeye area, backfat, and weight. To account for simultaneity and contemporaneous error correlation, a system of growth equations for backfat, ribeye area, and weight is estimated using three-stage least squares (3SLS) (Greene, 1997). Little variation was observed in *KPH* across the actual marketing dates, gender, or genotype from our study cattle. Consequently, *KPH* is held constant at actual post-slaughter values.

Bruns, Pritchard, and Boggs (2004) report carcass characteristics as a function of weight. Following their approach, we estimate *BF* and *REA* as a function of weight. Weight, *W*, is estimated as a function of *DOF*. The specified system is given as:

$$\begin{aligned}
 (3) \quad \log(BF_i) &= \left(c(1) + c(2) \times CT_i + c(3) \times TT_i + c(4) \times SEX_i + c(5) \right. \\
 &\quad \times source + c(6) \times nrtreat_i + c(7) \times restreat_i \Big) \\
 &\quad \times \log(W_i) + c(8) + c(9) \times \log(BF_i(-1)) + \varepsilon_{BF_i}, \\
 REA_i &= \left(c(10) + c(11) \times CT_i + c(12) \times TT_i + c(13) \times SEX_i + c(14) \right. \\
 &\quad \times source + c(15) \times nrtreat_i + c(16) \times restreat_i \Big) \\
 &\quad \times \log(W_i) + c(17) + \varepsilon_{REA_i}, \\
 \log(W_i) &= c(18) + c(19) \times CT_i + c(20) \times TT_i + c(21) \times SEX_i + c(22) \\
 &\quad \times \log(DOF_i) + c(23) \times \log(W_i(-1)) + c(24) \times source + c(25) \\
 &\quad \times nrtreat_i + c(26) \times restreat_i + \varepsilon_{W_i}.
 \end{aligned}$$

Dummy variables *CT* and *TT* indicate heterozygous and homozygous “fat” genotypes, and *SEX* denotes gender (steer = 0); *source* = 0 indicates purchased calves; the variables *nrtreat* and *restreat* represent the number of times each animal was treated for non-respiratory and respiratory ailments, respectively; and live weight is denoted by *W* and later converted to carcass weight (*HCW*) assuming a 62.5% dressing percentage.

Serial measurements of marbling were not taken. While it is possible to take ultrasound measurements of intramuscular fat, these measurements are not considered reliable. Reported correlations between ultrasonic intramuscular fat measures and carcass marbling score have ranged from 0.35 to 0.87 (Williams, 2002). In our study, only post-slaughter marbling scores were taken over the four marketing dates. Consequently, it is difficult to estimate marbling score and the resulting quality grade.

Table 2. Average Actual Cattle Weights and Measurements

Description/Variable	LOT 1			LOT 2			LOT 3		
	CC	CT	TT	CC	CT	TT	CC	CT	TT
Number	30	83	83	29	69	52	84	145	45
W initial (pounds)	604.37	599.51	592.70	558.69	568.48	574.25	598.77	598.51	661.69
BF initial (inches)	0.103	0.105	0.109	0.121	0.133	0.142	0.137	0.130	0.155
REA initial (inches ²)	10.22	7.81	7.88	7.56	7.63	7.49	7.94	8.23	8.38
HCW (pounds)	794.3	777.71	780.81	716.10	721.15	727.23	718.20	724.43	741.09
BF final (inches)	0.495	0.531	0.552	0.541	0.570	0.638	0.490	0.519	0.546
REA final (inches ²)	12.65	11.88	11.70	12.78	12.60	12.20	13.73	13.36	13.17
KPH (%)	1.97	2.03	1.88	1.83	1.99	2.00	1.97	2.05	2.04
YG (calculated, 1–5 scale)	2.80	2.93	2.98	2.72	2.81	2.98	2.48	2.61	2.98
MS ^a	454.0	440.4	456.4	473.1	462.2	476.5	429.8	443.6	470.0
DOF actual	192.9	194.0	197.7	188.5	187.8	186.2	194.7	192.5	186.2
Average Profit as Sold:									
Low Price	32.50	22.47	53.65	24.40	14.71	30.36	11.28	11.03	30.60
Medium Price	94.74	79.47	119.44	77.11	55.03	91.34	45.77	48.13	78.76
High Price	162.74	145.51	191.21	138.78	112.10	156.59	96.61	102.91	137.11

Notes: Lot 1 = home-raised steers, Lot 2 = home-raised heifers, and Lot 3 = purchased heifers; CC = lean genotype, CT = heterozygous or mixed genotype, and TT = fat genotype. The *t*-test ($\alpha = 0.05$) results indicate that Lot 1 initial REA and final REA differ across genotype, Lot 2 final BF differs across genotype, and Lot 3 initial W, initial REA, and MS differ across genotype.

^a Marble score (MS): 300 = slight 0 (Select), 400 = small 0 (low Choice), and 500 = modest 0 (average Choice).

Instead, we employ data from Bruns, Pritchard, and Boggs (2004) to estimate changes in marbling score due to changes in days-on-feed. The resulting curve is expressed as:

$$(4) \quad \Delta MS_i = \left(0.0029 e^{5.87 + 0.0029 \times DOF_i} \right) \Delta DOF_i.$$

Hence, (4) gives the change in post-slaughter marbling score as days-on-feed varies. Using (4), actual post-slaughter marbling scores can then be adjusted to various days-on-feed (more or less *DOF* than the actual *DOF* at marketing) as:

$$(5) \quad MS_{DOF_i} = \text{actual } MS_i + \Delta MS_i.$$

As reported in table 2, *TT* cattle did have higher marbling scores. By using actual post-slaughter marbling scores and simulating changes according to (5), the relative differences in marbling score across genotypes are maintained. However, we acknowledge that the rate of marbling deposition may vary across genotypes, with *TT* likely depositing most rapidly. While potentially distorting for large changes in days-on-feed from the actual marketing age, the approximated marbling score should be fairly accurate nearby the actual marketing age.

Regression Results

The model specified in (3) was estimated twice, with and without genotypic information. The resulting parameter estimates and standard errors are reported in table 3. Most variables are significant at $p = 0.01$. In the model considering genotypic information, genotype is significant in two of the three equations. Lagged dependent variables are significant in all equations. Treatments for ailments are mostly insignificant, which is likely due to overall good health of the herd and aggressive treatment of suspected ailments. The exception is for respiratory treatments (*restreat*) negatively influencing weights ($p = 0.097$). Hiefers ($SEX = 1$) had significantly greater *BF* and *REA* and lower *W* ($p < 0.001$ for all equations). The *source* variable also impacted characteristics. Home-raised calves had smaller ribeyes ($p < 0.001$), had more backfat ($p < 0.001$), and were lighter ($p = 0.002$).

The hypothesized and previously reported relationship between carcass traits and leptin genotype are confirmed. In the estimation, *CT* and *TT* dummy variables have a negative influence on ribeye area ($p = 0.017$ and $p < 0.001$, respectively), and the *TT* variable positively influences backfat ($p = 0.024$). Weights are also positively influenced by the *TT* genotype ($p = 0.089$). Following previous studies, our results suggest that the *C*-allele tends toward increased muscle size and the *T*-allele tends toward increased fat deposition.

Economic Model

The estimated growth models for ribeye area, backfat, weight, and marbling score are used to simulate carcass traits to days-on-feed of 160 to 220, both with and without genotypic information. Then, the simulated carcass characteristics are used to compute profit, as in (1), for both information scenarios and the three base price levels. A grid search is employed to find the *DOF* for each animal to maximize equation (1). For each

Table 3. Full-Information Maximum-Likelihood Regression Results

Variable	With Genotype			Without Genotype		
	$\log(BF)$	REA	$\log(W)$	$\log(BF)$	REA	$\log(W)$
Intercept	-12.705*** (0.174)	-190.897*** (3.813)	1.834*** (0.120)	-12.714*** (0.174)	-190.704*** (3.821)	0.158*** (0.002)
$CT \times \log(W)$	0.005 (0.003)	-0.175** (0.073)	—	—	—	—
$TCT \times \log(W)$	0.009** (0.004)	-0.346*** (0.085)	—	—	—	—
$SEX \times \log(W)$	0.039*** (0.003)	0.620*** (0.071)	—	0.039*** (0.003)	0.628*** (0.071)	—
$\log(W)$	2.029*** (0.030)	43.126*** (0.635)	—	2.035*** (0.029)	42.928*** (0.633)	—
$nrtreat \times \log(W)$	-0.004 (0.003)	0.041 (0.062)	—	-0.004 (0.003)	0.034 (0.071)	—
$restreat \times \log(W)$	-0.004 (0.003)	0.054 (0.072)	—	-0.005 (0.003)	0.079 (0.071)	—
$source \times \log(W)$	0.012*** (0.003)	-0.451*** (0.068)	—	0.013*** (0.003)	-0.491*** (0.068)	—
CT	—	—	-0.004 (0.006)	—	—	—
TT	—	—	0.011* (0.089)	—	—	—
$nrtreat$	—	—	0.004 (0.005)	—	—	0.004 (0.005)
$restreat$	—	—	-0.010 (0.006)	—	—	-0.011* (0.006)
SEX	—	—	-0.025*** (0.006)	—	—	-0.024*** (0.006)
$source$	—	—	-0.018*** (0.006)	—	—	-0.016*** (0.006)
$\log(BF(-1))$	0.056*** (0.019)	—	—	0.058*** (0.019)	—	—
$\log(DOF)$	—	—	0.158*** (0.002)	—	—	0.158*** (0.002)
$\log(W(-1))$	—	—	0.598*** (0.019)	—	—	0.600*** (0.019)
R^2	0.781	0.780	0.908	0.780	0.778	0.908

Notes: Single, double, and triple asterisks (*) denote significance at $p = 0.1$, 0.05, and 0.01, respectively. Values in parentheses are standard errors.

lot, maximum expected profits are compared across genotypes for the information scenarios. Next, the second optimization model, as in (5) and (6), finds optimal DOF and maximum profit when head sold per date are constrained to potload quantities (45 head).

Fed cattle prices were taken from USDA/AMS (2004). To assess the sensitivity of our results, three different base price levels were used in the optimization: base prices (dressed weight) of \$112/cwt (low), \$128/cwt (medium), and \$144/cwt (high). Feeder cattle prices of \$78.87/cwt (low), \$87.87/cwt (medium), and \$97.87/cwt (high) were also derived from USDA/AMS (2004). A price differential of \$5/cwt was assumed for steers

Table 4. Yield Grade Premiums/Discounts (\$/cwt)

USDA Yield Grade	Price Level		
	Low	Medium	High
1	3.18	4.77	7.20
2	1.58	2.38	2.75
3	0.00	0.00	0.00
4	-14.04	-17.55	-20.00
5	-18.32	-22.90	-25.00

Source: Derived from USDA/AMS (2004).

Table 5. Quality Grade Premiums/Discounts (\$/cwt)

USDA Quality Grade	Price Level		
	Low	Medium	High
Prime	12.20	18.30	24.52
Avg. Choice+ ^a	0.68	1.02	2.21
Choice	0.00	0.00	0.00
Select	-6.45	-8.07	-9.69
Standard	-13.89	-20.84	-30.00

Source: Derived from USDA/AMS (2004).

^a Carcasses grading average or high Choice.

vs. heifer calves (North Dakota Agricultural Statistics Service, 2004). Yield grade premiums and discounts are reported in table 4, and quality grade premiums and discounts are reported in table 5.

Actual costs from the producer were used to determine daily feed costs of \$1.36 per head per day. Yardage costs of \$0.29 per head per day were assumed. An interest rate of 5.5% was used for the opportunity cost of investment in calves and incurred operating expenses. The second optimization performed considers marketing constraints. Given the relatively high cost of transporting cattle from a feedlot to a processing plant, feedlot operators generally market cattle in “potloads” of approximately 45 head. (Weight restrictions on over-the-road semi-tractor trailers limit the number of head.) Incorporating potload sales converts the optimization model into an integer programming model that chooses the dates of sales and the approximately 45 head sold on each marketing date. Mathematically, the objective function and constraints are:

$$(6) \quad \text{Max} \sum_{a_{ik}, b_k} a_{ik} \times \pi_{ik}$$

subject to:

$$(7) \quad \begin{aligned} \sum_k a_{ik} &= 1 \forall i, \\ \sum_k b_k &\leq 14, \\ \sum_i a_{ik} &\leq 45 \times b_k \forall k, \end{aligned}$$

where a_{ik} is an integer variable equal to 1 on calf i 's market date and zero otherwise, and b_k is an integer variable equal to 1 if cattle are marketed on date k and zero otherwise. Given the number of cattle in the study (590), no more than 14 potloads of cattle can be marketed.

Economic Results

For the unconstrained profit-maximization model, the average optimal days-on-feed are reported in panel A of table 6. Average optimal days-on-feed are higher for *CC* and *CT* genotype cattle than *TT* for lots 1 and 3. For steers (lot 1), average optimal days-on-feed

Table 6. Optimal Days-on-Feed With and Without Genotypic Information by Lot and Price Level

Price	Genotype	Lot 1		Lot 2		Lot 3	
		With	Without	With	Without	With	Without
PANEL A. Unconstrained Profit Maximization:							
Low	CC	178.50	178.50	171.35	175.21	182.06	182.11
	CT	179.43	179.43	173.73	173.73	178.03	178.52
	TT	176.60	175.85	172.00	170.92	171.07	170.67
Medium	CC	179.23	179.23	171.35	175.21	183.32	183.96
	CT	180.07	180.34	174.49	174.49	179.15	180.12
	TT	177.64	177.64	172.00	170.92	172.84	174.02
High	CC	180.10	180.10	175.97	175.97	186.92	186.92
	CT	180.34	180.98	178.71	179.54	181.72	182.20
	TT	178.70	177.64	172.00	172.00	174.11	174.02
PANEL B. Potload Constrained Profit Maximization:							
Low	CC	182.00	181.80	175.21	177.07	186.54	185.77
	CT	182.93	183.19	176.55	175.73	181.24	181.23
	TT	180.72	180.85	174.56	171.56	175.84	175.67
Medium	CC	181.30	182.73	176.90	179.52	187.23	189.49
	CT	183.02	184.08	177.48	180.44	182.01	182.96
	TT	180.72	183.23	174.44	173.15	176.07	177.93
High	CC	181.30	182.73	176.90	179.52	187.23	189.49
	CT	183.02	184.08	177.48	180.44	182.01	182.96
	TT	180.72	183.23	174.44	173.15	176.07	177.93

Notes: Lot 1 = home-raised steers, Lot 2 = home-raised heifers, and Lot 3 = purchased heifers; *CC* = lean genotype, *CT* = heterozygous or mixed genotype, and *TT* = fat genotype.

was about two to three days longer for *CT* cattle than for *TT* cattle and about one-quarter of a day to one day longer than for *CC* cattle. This finding contrasts with the actual days-on-feed where *TT* cattle were fed the longest. In lot 2, *TT* heifers are fed longer than *CC* but shorter than *CT* heifers. The comparisons between *CC* and *CT* are mixed. In lot 3, *CC* and *CT* heifers are fed from 5 to 12 days longer than *TT* heifers.

Between information scenarios, little difference is observed in optimal days-on-feed. In comparing optimal *DOF* between the with- and without-genotypic information scenarios, 10 of the 27 comparisons show no difference in *DOF*. For another 10 of the 27 comparisons, the without-genotypic information scenarios have longer *DOF* than the comparable with-genotypic information scenarios. And for the remaining seven comparisons, the with-genotypic information scenarios have longer *DOF* than the comparable without-genotypic information scenarios. The largest difference is just under four days, but most of the differences, 22 of 27 comparisons, are less than one day.

The unconstrained maximum profits, as in (1), are reported in panel A of table 7. For both information scenarios, the three price levels and all lots, average profit is highest for *TT* cattle. Although fed roughly the same time as the other genotypes, higher prices per pound are received for *TT* cattle due to higher quality grade. In figures 1 and 2, the respective distributions of yield and quality grades by genotype are reported for the medium price grid. As observed from these graphics, *TT* cattle are the most likely to be YG3, but are also the most likely to grade Choice or average Choice+ and the least likely to grade Select. Given little difference in days-on-feed and hot carcass weight, the higher

Table 7. Average Maximum Profit With and Without Genotypic Information by Lot and Price Level

		Lot 1		Lot 2		Lot 3	
Price	Genotype	With	Without	With	Without	With	Without
PANEL A. Unconstrained Profit Maximization (\$/head):							
Low	CC	58.74	50.69	38.12	25.83	8.85	1.16
	CT	42.85	40.85	17.49	9.37	15.62	6.14
	TT	82.26	77.85	52.38	42.79	46.69	36.15
Medium	CC	125.09	120.76	101.15	94.91	69.57	66.35
	CT	109.28	107.88	78.69	74.12	75.41	71.11
	TT	153.08	150.26	117.09	111.42	105.71	99.51
High	CC	191.51	191.51	164.44	164.44	130.57	130.57
	CT	175.77	175.76	140.05	140.05	135.41	135.32
	TT	224.01	223.98	181.81	181.81	164.87	164.54
PANEL B. Potload Constrained Profit Maximization (\$/head):							
Low	CC	56.01	53.78	35.85	34.37	6.05	0.52
	CT	39.88	46.04	15.32	22.43	13.20	19.25
	TT	79.34	56.37	49.78	29.90	43.76	26.19
Medium	CC	122.67	120.29	99.03	97.87	66.48	61.33
	CT	106.64	113.77	76.93	84.61	72.92	78.27
	TT	149.53	124.39	114.84	91.27	102.87	83.90
High	CC	189.98	186.63	163.01	160.90	128.15	121.82
	CT	173.01	181.66	138.39	146.80	133.17	140.80
	TT	221.73	191.33	179.81	152.63	162.27	138.40
PANEL C. Potload Weighted Average Profit (\$/head):							
		With Genotype		Without Genotype			
Low	ALL	30.97		22.97			
Medium	ALL	33.28		30.31			
High	ALL	157.31		156.65			

Notes: Lot 1 = home-raised steers, Lot 2 = home-raised heifers, and Lot 3 = purchased heifers; CC = lean genotype, CT = heterozygous or mixed genotype, and TT = fat genotype.

quality premiums and fewer discounts for Select offset lower yield grade premiums. Consequently, *TT* cattle are the most profitable. *CT* cattle are likely to be YG3 and are the least likely to reach average Choice, high Choice, and Prime premiums. Also, *CT* cattle earn fewer yield grade premiums than *CC* cattle. The result is that *CT* cattle are the least profitable. *CC* cattle are the most likely to grade YG2 and the most likely to grade Select. In net, *CC* cattle profitability is less than *TT* but higher than *CT* cattle.

Heifers (lots 2 and 3) earn less profit than steers in all scenarios. In table 7, optimal days-on-feed are lower for heifers, which reduced their feed cost but also resulted in lighter carcass weights. (Lighter weights are also due to lower rates of gain for heifers.) Heifers earn more premiums for high quality grade but also more discounts for low quality grade. In net, the revenue for heifers per head was lower than for steers with comparable genotype.

Using table 7, we can determine the value of leptin genotypic information. Across information scenarios, the value of genotypic information ranges from less than \$0.01 per head with a high price to \$12.29 (lot 2 *CC* heifers and a low carcass price). The average difference in profit per head across the 590 cattle (196 steers and 394 heifers)

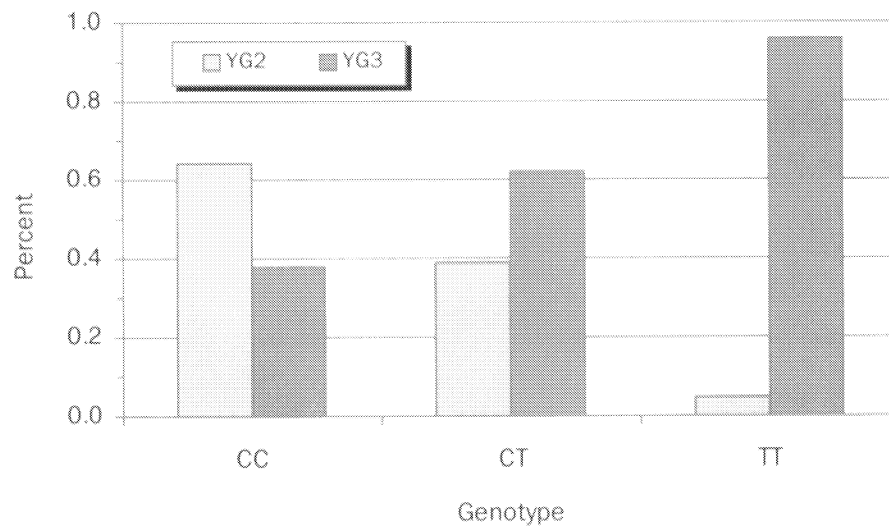


Figure 1. Unconstrained profit maximization yield grade distribution by genotype (medium price)

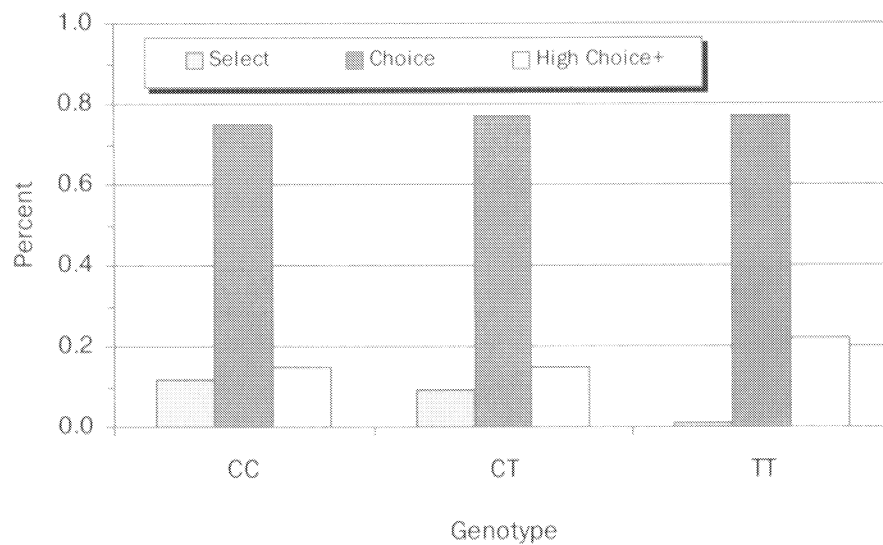


Figure 2. Unconstrained profit maximization quality grade distribution by genotype (medium price)

is \$2.86 (high price), \$7.43 (medium price), and \$10.87 (low price). These small differences are due to little differences in optimal days-on-feed between the information scenarios. In terms of influencing marketing date decisions, leptin genotype appears to be of low value.

Leptin genotype appears to be of economic relevance in valuing feeder cattle. Between genotypes, the *TT* cattle are more profitable than *CC* or *CT* cattle, and *CC* cattle are more profitable than *CT* cattle—except in lot 3 where *CC* cattle are less profitable than *CT*. For the same lot and price grid, the differences in profitability due to genotype range from \$14.26 (*TT* vs. *CC* in lot 2, low price) to \$48.25 (*TT* vs. *CT* in lot 1, high price). In short, *TT* cattle are more profitable, so a feedlot operator would be willing to pay more for *TT* feeder calves.

When the cattle are constrained to marketing in potloads, as in (6) and (7), results are similar to the individually optimized case. In panel B of table 6, average optimal days-on-feed are given by genotype, gender, and information scenario. Average optimal *DOF* increases from the individually optimized profit model. The increases range from one day to just about six days in comparison to the model given by (1) and reported in panel A of table 6. As previously, optimal days-on-feed increase with price and are usually higher for *CT* and *CC* than for *TT* cattle.

Maximum profits under the potload quantity constrained model are reported in table 7, panel B. Similar to the individually optimized profits model, the *TT* cattle have the highest profit for each information scenario and gender, and *CT* cattle have the lowest profits—except for lot 3 where *CC* were less profitable. The differences across information scenarios are again fairly small, but caution should be exercised in interpreting these results. There is no guarantee for a given genotype, lot, and price combination that the unconstrained model will have a higher profit than its constrained equivalent. The only guarantee, for any given price grid, is that total profit across all genotype and lot combinations will be higher for the unconstrained model.

At the bottom of table 7 (panel C), we report profit per head for the price grids and information scenarios. Between information scenarios, the differences in average profits range from \$0.66 to \$8 per head. As with the unconstrained profit-maximization model, genotype does not appear to have a large economic value in determining optimal marketing dates. Again, some caution is advised in generalizing the actual values to other feedlots because our data come from one feedlot, one manager, and one environment.

Also, similar to the unconstrained maximization, *TT* cattle are the most profitable when marketing is constrained to potloads. It is worth noting that when genotype is ignored, *CC* cattle are projected to be more profitable than *TT* cattle in some lots and price levels, a reversal of the ranking when genotypic information is considered. Profits in the potload constrained model are lower than in the unconstrained model. Yet, the difference in profits across genotypes within a lot and price are largely unaffected.

To summarize, leptin genotypic information has little impact on optimal marketing dates for fed cattle. However, when comparing across genotypes, *TT* cattle have higher value carcasses and slightly earlier optimal harvest dates, leading to higher profits.

Summary and Implications

Improved understanding of genetics may lead to improved profitability for beef producers. To date, few genetic polymorphisms have been studied to determine their impact on the profitability of beef cattle. One of the first, a polymorphism in the leptin gene originally

was aggressively marketed as a “marbling gene.” Our results and those of other researchers show that this gene is instead a “fatness gene.” It increases both an economically desirable trait, marbling, and an economically undesirable trait, external carcass fat thickness. Beef producers and their breed associations in the United States and Canada will face many decisions in the near future regarding which genes, including possibly leptin gene polymorphisms, should be exploited to improve marketability and profitability. Currently, breed, phenotype, and Expected Progeny Differences (EPDs) are used by beef producers and breeders. Profitably utilizing specific genetic information, such as polymorphisms, requires trading off the desirable impacts with undesirable impacts given current economic conditions—i.e., prices.

Here, we investigate the economic value of a leptin gene polymorphism to feedlot operators. First, we consider how optimal marketing dates and profits are affected by utilizing leptin genotypic information. Second, we examine how leptin genotypes compare in terms of profit. Data from 590 crossbred steers and heifers are used to estimate growth curves for economically relevant carcass traits. Profit-maximization models determine optimal marketing dates and maximum profit, both with and without genotypic knowledge.

Our results suggest that leptin genotypic information has low value when determining optimal marketing dates. However, leptin genotype does impact the value of a finished steer or heifer. The results show that fat or *TT* genotype cattle were more valuable than *CC* or *CT* cattle when priced on quality grids. Also, *CC* cattle were more profitable than *CT* cattle. Given that this study considered one feedlot and price grids that reward marbling, our quantitative results should not be generalized to other locations and all price grids. Further analyses across a wide range of environments, managers, and price grids are necessary to definitively determine the value of one genotype versus another. However, our results do indicate that leptin genotype plays a role in determining the value of a fed steer or heifer.

Collection of genetic information is costly. Commercial laboratories charge up to \$50 per sample to determine one single nucleotide polymorphism (SNP). Over 20 SNPs in the leptin gene alone have been discovered (Konfortov, Licence, and Miller, 1999). While it is likely that most of these SNPs are economically irrelevant, others are considered biologically “non-conservative” and may influence carcass traits and value and costs of production, such as feed intake and efficiency. Further, other SNPs on several other genes likely play varying roles in fat deposition and marbling. When various combinations of SNPs, called “haplotypes,” are evaluated, the cost of genotyping/haplotyping increases.

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