THE ECONOMIC VALUE OF IGENITY PANEL
GENOTYPIC INFORMATION
FOR FED CATTLE

By

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Bachelor of Science in Food & Resource Economics

University of Florida

Gainesville, Florida

2006

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, 2010

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ACKNOWLEDGMENTS

I would like to thank my graduate adviser, Dr. Eric DeVuyst, for providing assistance throughout the duration of this thesis. In addition to the time, patience, and insight he contributed to my research, I thank him for his friendship. I would like to extend my appreciation to my committee members, Dr. Jayson Lusk, Dr. Wade Brorsen, and Dr. Udaya DeSilva, for their time and comments that they contributed to the improvement of my research.

I thank the professors, faculty, and staff in the Department of Agricultural Economics at Oklahoma State University. Thanks for the guidance and willingness to answer all of my questions. I would like to especially thank some of the graduate students from the department including Brenna Ellison, Cindi Browne, Mary Wilson, Kwame Acheampong, and Tyler Klain for their helpfulness and friendship. I wish them the best of luck in their future endeavors.

I would like to thank my parents, Dennis and Debbie Holt, for always supporting and loving me. Finally, I would like to especially thank my beautiful wife, Jessica Holt, for her endless love, encouragement, and patience she has given to me throughout my career at Oklahoma State University.

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CHAPTER I

INTRODUCTION

Advances in molecular genetics have led to the identification of genetic markers that influence economically-relevant traits in beef cattle (Garrick and Van Eenennaam 2008; Van Eenennaam 2007). Traits of economic significance include carcass marbling (intramuscular fat), muscle development, beef tenderness, weight, and fat cover. A genetic marker or single nucleotide polymorphism (SNP) is a nucleotide at a specific location in a gene. Polymorphisms or “mutations” can affect an animal’s biological characteristics. The identification of DNA sequences such as SNPs may allow for the improvement of economically-relevant traits in beef cattle. Since economic value is influenced by quality and growth traits, genetics determine, in part, the profitability of fed cattle.

Using DNA information, cattle operators now have the tools to select cattle with the potential to earn a high profit. Through genetic marker-assisted selection, cattle operators could make better selection, management, and marketing decisions by predicting potential carcass and growth traits. Moreover, genetic information allows feedlot operators to select and manage their cattle based on traits of interest.

Genetic tests could assist feedlot operators in predicting which cattle grow faster and convert feed into weight more effectively, allowing for improved management.

With the advancement of technology, commercial genetics testing services are becoming available to beef cattle operators. Commercial genetics companies include MetaMorphix Inc. (MMI) Genomics, Merial Igenity, and Pfizer Animal Genetics (Bovigen) GeneStar. Specifically, Merial Igenity offers beef cattle genetics marker panels for carcass traits such as marbling, quality grade, yield grade, fat thickness, ribeye area, and tenderness. Igenity also offers feed efficiency marker panels for residual feed intake and average daily gain.

According to a summary published by the National Beef Cattle Evaluation Consortium, Merial Igenity has 14 validated marker panels that are commercially available, while MMI offers two validated marker panels, and Pfizer offers three validated marker panels (NBCEC 2009). Because of proprietary information reasons, it is unclear as to the exact SNPs that are utilized to construct each panel, so an analysis cannot be evaluated based on SNPs within the panels. Instead, research must be conducted to evaluate the information contained in the panel scores as reported by the company. These scores are the information that is available to cattle operators who make marketing and management decisions.

Fed cattle profits are affected by carcass traits such as marbling, muscling, weight, and 12^{th} rib fat thickness. Further, feed efficiency measures such average daily gain and residual feed intake affect profits by potentially reducing feedlot costs. Igenity has panels that predict the magnitude of carcass traits and feed efficiency measures, but to date, no studies have quantified the economic impact of these panels on fed cattle profits.

Problem Statement

While commercial genetics testing services are offered to beef cattle operators, the economic implications from utilizing this knowledge have not been quantified. Only a few studies have estimated the economics of commercial genetics testing in beef cattle (e.g., DeVuyst et al. 2007; Lusk 2007). Lusk (2007) analyzed one SNP and a microsatellite on the leptin gene in a sample of commercial feedlot cattle. DeVuyst et al. (2007) also investigated the influence of a leptin SNP on cow/calf profitability. These studies only consider the economic implications from one or two genetic markers and not a full panel of genetic markers, such as in the Igenity beef panels.

The economic differences in fed cattle profits due to differences in genetic marker panels have not been investigated. There is uncertainty among beef cattle operators as to the economic gain they could receive due to differences in the genetics in their herds of cattle. Therefore, there is a need to provide the beef industry with economic information pertaining to the value of the genetic testing services and the effect on fed cattle profitability.

Objectives

The primary objective of this research is to determine the value of Igenity panel genotypic information on fed cattle profits. The specific objectives of this research are to: (1) empirically model fed cattle profits; (2) determine direct and indirect effects from the Igenity beef panels on fed cattle profits; (3) determine the total marginal effects of Igenity panel scores on fed cattle profits; (4) determine the sensitivity of the model by varying fed cattle grid prices, market base prices, and daily feedlot costs of gain.

Summary of Methods

Data from 2201 fed cattle were used to estimate a profit function with days-on-feed, placement weight, placement age, Igenity panels, sire and dam breeds, and source as independent variables. As days-on-feed and placement weight may be influenced by Igenity panel markers, separate equations were estimated with Igenity panels as independent variables. The coefficients from these regressions were used to estimate impact of the Igenity panels on fed cattle profits, days-on-feed, and placement weight.

Using the estimated models of profit, days-on-feed, and placement weight, total marginal effects were found by totally differentiating the profit function and substituting in estimated coefficients from the regression models. Prices for fed cattle, quality and yield grade premiums and discounts, and hot carcass weight were varied over a range of values to assess the sensitivity of estimated effects of Igenity panels on profit.

Outline of Study

In the following chapters, the research is presented as follows. In chapter II, a discussion is presented on the influence of genetic markers on cattle biology and economic studies on genetic marker assisted selection. Information on the Merial Igenity marker panels is also provided. Chapter III discusses the procedures and data set used to accomplish the objectives. Chapter III also presents the conceptual framework and empirical models used for determining the Igenity panels' direct and indirect effects on fed cattle profitability. Chapter IV discusses the regression estimates and calculating total marginal profits. Chapter V discusses the conclusions of the study and suggests limitations and future motivation and direction for research.

CHAPTER II

REVIEW OF LITERATURE

Phenotype is any observable trait or characteristic that results from the expression of the organism's genetic makeup and management. Carcass marbling, weight, and fat cover are economic traits that are affected by these factors. Since economically relevant traits are influenced by genes, genetics determine, in part, the profitability of livestock. In the sections below, a general overview of molecular genetics is provided with an emphasis on cattle genetics and economic studies that have used bovine genetics information.

Molecular Genetics and Beef Cattle

A gene is a strand of deoxyribonucleic acid (DNA) and is a set of instructions for encoding certain components of cells, such as protein molecules. Genes are comprised of chains of nucleotides. The four nucleotides making up DNA are adenine (A), cytosine (C), guanine (G), and thymine (T). A sequence of three nucleotides regulates the insertion of an amino acid into a protein molecule that is being synthesized. Changes in any one of these three nucleotides can change the amino acid and the functionality of the protein (Van Eenennaam 2004).

A genetic marker or single nucleotide polymorphism (SNP) is a nucleotide at a specific location in a gene. A mutation occurs when nucleotides are replaced by other nucleotides and can cause an alteration of amino acids and proteins. Some of these polymorphisms affect the expression of biological traits in animals. And, some of these genetic mutations affect quality and growth traits in beef cattle.

Scientists have developed tests to find differences in genes that affect quality traits in beef cattle. For example, Page et al. (2002) suggested that mutations of the calpain (*CAPN1*) gene were associated with variations in beef tenderness. The researchers noted that use of genetic markers for selective breeding may reduce the number of calves with unfavorable meat tenderness. In addition, Casas et al. (2006) researched the association of mutations developed at the calpastatin *(CAST)* and calpain *(CAPN1)* genes with meat tenderness and palatability traits (tenderness score, juiciness, and flavor intensity) in populations of cattle with diverse genetic backgrounds. The researchers concluded that genetic markers in the *CAST* and *CAPN1* genes are suitable for identifying animals with the genetic potential to produce cuts of beef that are tender.

The mutation of a particular sequence of the leptin gene can alter growth and quality traits in beef cattle. In a study by Kulig and Kmieć (2007), 129 Limousin calves were used to evaluate the effect of two leptin gene SNPs on weight and average daily gain. Findings revealed that one SNP significantly affected weight at 210 days of age and average daily gain between three and 210 days of age. The results further indicated that selection for a leptin SNP on a TT allele nucleotide might contribute to an improved body weight. Further, Buchanan et al. (2002) have shown that alleles of the "*BM1500* microsatellite" of the leptin gene in cattle are associated with carcass fat measures within a herd size of 154 beef bulls. A microsatellite is a genetic marker and a term used to describe a repeating sequence of DNA nucleotide base pairs. In the study, the thymine (T) nucleotide was associated with fatter (higher marbling) carcasses, while the cytosine (C) nucleotide was associated with leaner (lower marbling) carcasses. Furthermore, Kononoff et al. (2005) studied the effect of a leptin gene mutation on economically viable carcass traits in finished steers and heifers. The scope of the study was to determine the effects of a leptin single nucleotide polymorphism (SNP) on Canadian yield grades, quality grades, and weights of finished beef cattle. They found that 7.6% more TT carcasses graded Canadian AAA or higher than CT carcasses.

Commercial Genetic Testing Services for Beef Cattle

Companies such as MetaMorphix Inc. (MMI) Genomics, Merial Igenity, and Pfizer Animal Genetics (Bovigen) GeneStar offer genetic testing services for beef cattle. Each company has developed various marker panels to predict phenotypic expression of economically-important quality traits.

Van Eenennaam et al. (2007) researched the effectiveness of three commercially-available genetic marker panels (GeneStar quality grade, GeneStar tenderness, and Igenity tenderness) on associated phenotypes. In the GeneStar quality grade panel, the genotype results were not associated with marbling score, but the marker panel was significant with increased quality grade (percentage of cattle grading Choice or Prime). Furthermore, the GeneStar Tenderness and Igenity marker panels share two common μ-calpain SNPs, but each has a different calpastatin SNP. In both panels, there were highly significant ($p \leq 0.001$) associations of the calpastatin marker and the μ-calpain haplotype with beef tenderness.

Nineteen commercial marker panels have been comprehensively researched and validated in U.S. beef cattle herds according to a summary published by the National Beef Cattle Evaluation Consortium (NBCEC 2009). Merial Igenity has 14 marker panels that are commercially available, while MMI offers two panels and Pfizer offers three panels.

According to the Merial Igenity online marketing guide, the service provides cattle producers with a comprehensive genetic profile of individual animals (Igenity, 2010). The Merial Igenity beef panels include analyses for economically important carcass composition traits including marbling, quality grade, yield grade, fat thickness, ribeye area, and tenderness. Feed efficiency marker panels for residual feed intake and average daily gain are also available. It has been validated that commercial panels are useful tools in predicting traits of interest, but the usefulness in economic decision making has not been assessed and quantified.

Economic Analysis of Genetic Information

The economics of genetic information is still relatively new and only a few studies have been published. Research by Lusk (2007) and DeVuyst et al. (2007) investigate whether fed cattle profit was associated with single nucleotide polymorphisms (SNPs) in the leptin gene. Lusk (2007) analyzed one SNP and a microsatellite of the leptin gene in a sample of 1,668 commercial feedlot cattle. Lusk found that use of genotypic information potentially adds \$28 per head for heifers and \$23 per head for steers if producers were willing to selectively group and feed cattle based on genotype. Higher values of $60 per head were realized if animals were optimally marketed based on genetic traits, but there was no value for choosing an optimal marketing date. Further, DeVuyst et al. (2007) performed a study on the leptin genotype of 590 crossbred heifers and steers. A simulation study was performed to replicate carcass traits to a variety of days-on-feed. Profit was then computed under three different pricing grids. DeVuyst et al. found that leptin genotyping affects value in beef cattle by as much as $48 per head.

Studies by Lusk (2007) and DeVuyst et al. (2007) analyzed the effects of one or two genetic markers on fed cattle profit. For example, Lusk (2007) analyzed one SNP and a microsatellite and DeVuyst et al. (2007) analyzed only one SNP of the leptin gene. In actuality, there are hundreds of SNPs across many genes that affect feedlot cattle performance. The results from both studies conclude that further research is needed in analyzing the value of gene testing across different procedures. Neither study analyzed marker panels provided by commercial gene testing companies nor the value that producers receive associated with those panels. In fairness to Lusk and DeVuyst et al., their analyses utilized the best genetic information available at the time of their studies.

The research reported used past studies as a guide on how market factors and understanding genetic markers can influence the price received for finished cattle. This research assessed the economic gain from utilizing information from commercial genetics marker panels. To date, no economic study has considered commercially available marker panels.

CHAPTER III

METHODOLOGY

To fulfill the objectives and test the hypotheses of this study, an economic analysis was conducted to evaluate the effect of each Igenity panel on fed cattle profits. Regression models with varying grid prices, base prices, and costs of gain were used to estimate profits for each head of cattle. Specifically, mixed linear models were used to estimate fed cattle profits given Igenity panel scores. Mixed linear models were also used to estimate days-on-feed and placement weight given Igenity panel scores.

Notation and Variables

The following notations are used throughout the remainder of this thesis.

i	Subscript indicating animal identification $i \in \{1,\ldots,2201\}$
ADG_i	Average daily gain for the i^{th} animal
AGE_{0i}	Age placed in feedlot for the i^{th} animal
DOF_i	Days-on-feed for the i^{th} animal
DOF_i^2	Days-on-feed squared for the i^{th} animal
DOF_i^3	Days-on-feed cubed for the i^{th} animal
DOF_i^4	Days-on-feed to the fourth power for the i^{th} animal

G_i	Dummy variable ε {0, 1} where $G_i = 1$ indicates i^{th} animal is a steer and $G_i = 0$ indicates i^{th} animal is a heifer
HCW_i	Hot carcass weight for the i^{th} animal
$\boldsymbol{IG}_i$	Vector of Igenity scores for the i^{th} animal where $\boldsymbol{IG}_i = (IG_{iREA}, IG_{iTEN}, IG_{iMAR}, IG_{iYDG}, IG_{iADG}, IG_{iRFI})$
IG_{ij}	Animal i's Igenity score for the j^{th} panel where j ε {$REA, TEN, MAR, YDG, ADG, RFI$}
IG_{iREA}	Igenity ribeye area panel score for the i^{th} animal
IG_{iTEN}	Igenity tenderness panel score for the i^{th} animal
IG_{iMAR}	Igenity marbling panel score for the i^{th} animal
IG_{iYDG}	Igenity yield grade panel score for the i^{th} animal
IG_{iADG}	Igenity average daily gain panel score for the i^{th} animal
IG_{iRFI}	Igenity residual feed intake panel score for the i^{th} animal
Wt_{0i}	Weight placed into the feedlot for the i^{th} animal
Wt_{0i}^2	Weight placed into the feedlot squared for the i^{th} animal

Conceptual Framework and Hypothesis

It is hypothesized that economically-relevant characteristics including cattle carcass traits and feedlot performance are functions of Igenity panel scores, other unknown genetics, and management. Fed cattle profit is determined by prices, carcass traits, and cattle performance in the feedlot.

Figure III-1 outlines the conceptual framework of this study. The figure illustrates how beef cattle feedlot operators are faced with information and other factors that could affect fed cattle profitability. For example, in the box to the left, phenotype determinants including Igenity panel scores, other genetics, and management affect cattle carcass traits (i.e., hot carcass weight, muscling, marbling) and feedlot performance (i.e., placement weight, average daily gain, and days-on-feed). When cattle purchasing costs, feed costs, yardage fees, and interest are subtracted, profits can be determined. Profits change with prices, carcass traits, and feedlot performance.

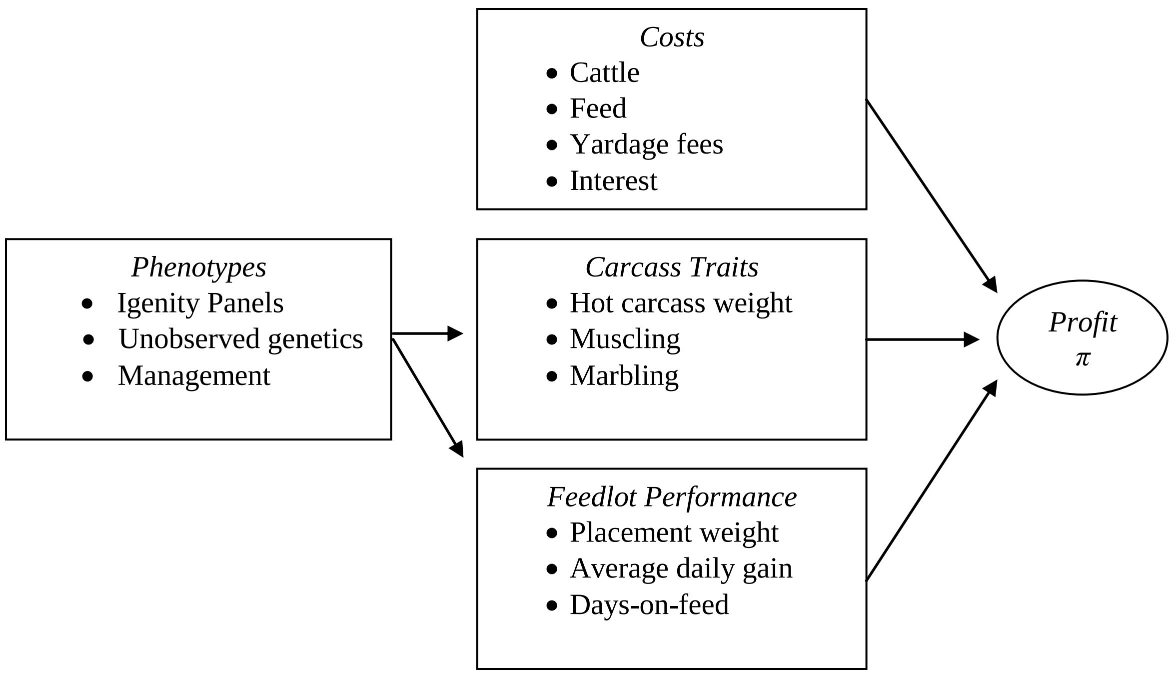

Figure III-1. Factors influencing fed cattle profitability

Feedlot operators could affect profitability by adjusting days-on-feed through a number of ways. As days-on-feed increase, carcass marbling will likely increase causing market quality grade to increase. Carcasses will earn a premium for high market quality grade scores, increasing profits. However, an increase in days-on-feed positively affects market yield grade. In this case, carcasses will receive a discount for high market yield grade scores, decreasing profits. A trade-off is made between improved quality grade and poorer yield grade. Further, days-on-feed will positively affect carcass weight. Fed cattle profits depend on the carcass weight, where discounts are given to heavy and/or light carcasses. Additionally, more days-on-feed increases feedlot costs (i.e., feed, labor, interest) and decreases profits.

Feedlot operators could also affect profitability by adjusting the weight that cattle are placed into the feedlot. The costs of feeding cattle will increase the longer they are on feed. When cattle have a heavier placement weight, average daily gain will be greater and days-on-feed will be less, resulting in greater profit. Heavier calves are more costly to purchase, reducing profits, on the other hand, smaller cattle with lighter placement weights will have greater days-on-feed, resulting in less profit, but have a lower cost of gain.

Steers have better average daily gain and feed efficiency than heifers. So, steers have a lower cost of gain, which increases profits. But steer calves are more expensive to purchase. Heifers on the other hand, have higher yield grade scores and are less expensive to purchase.

Feedlot operators are assumed to be profit maximizing by choosing and manipulating cattle days-on-feed and placement weight. However, both days-on-feed and placement weight may be functions of Igenity panel scores causing an indirect effect on fed cattle profits. Therefore, Igenity panels are hypothesized to be directly and indirectly influencing fed cattle profit. It is also hypothesized that both days-on-feed and placement weight are functions of Igenity panel scores given prices and gender.

Mathematically, the feedlot operator maximizes profit by choosing days-on feed and placement weight or

(1) $$\max_{\mathrm{DOF}_i,\, \mathrm{Wt}_{0i}} \pi_i = \pi_i\,(\mathrm{DOF}_i\,(\mathrm{IG}_i),\, \mathrm{Wt}_{0i}\,(\mathrm{IG}_i)\,|\mathrm{P}_i,\, \mathrm{G}_i,\, \mathrm{IG}_i)\ \forall\, i\ \varepsilon\ \{1,\ldots,\, 2201\}$$

where i is a subscript indicating animal identification i ε {1,…, 2201};

π_i is profit for the i^{th} animal;

DOF_i is days-on-feed for the i^{th} animal;

$\boldsymbol{IG}_i$ is a vector of Igenity scores for the i^{th} animal where

$\boldsymbol{IG}_i = (IG_{iREA}, IG_{iTEN}, IG_{iMAR}, IG_{iYDG}, IG_{iADG}, IG_{iRFI})$;

Wt_{0i} is the weight placed into the feedlot for the i^{th} animal;

G_i is gender for the i^{th} animal where $G_i = 1$ indicates steer and

$G_i = 0$ indicates heifer;

P_i is market price(s) for the i^{th} animal.

The first order conditions require $\frac{\partial \pi_i}{\partial \mathrm{DOF}_i} = 0$ and $\frac{\partial \pi_i}{\partial \mathrm{Wt}_{0i}} = 0$.

Estimating Fed Cattle Revenues

Fed cattle revenues were calculated using beef packer grid pricing scenarios. The grid pricing system rewards feedlot operators with premiums for cattle having more desirable carcass traits, while discounting cattle having less desirable carcass traits. Beef packers utilize grid pricing to achieve a uniform product with a high quality standard that meets consumer demand.

A grid starts with a base price per hundredweight. Price premiums and discounts are earned for quality grade, yield grade, and hot carcass weight. To estimate the revenues of fed cattle across different market conditions, five grid pricing levels (Grid 1

= Low; Grid 2 = Low/Average; Grid 3 = Average; Grid 4 = Average/High; Grid 5 = High) were paired with three base prices ($140, $145, and $150 per hundredweight) generating 15 different revenue scenarios. Low (Grid 1) price levels for quality grade, yield grade, and hot carcass weight were jointly evaluated. Low/average (Grid 2) price levels for quality grade, yield grade, and hot carcass weight were combined together, and so on. The quality grade premiums and discounts used in this study are presented in table III-1. The yield grade premiums and discounts used in this study are presented in table III-2. Finally, the hot carcass weight discounts used in this study are presented in table III-3.

Table III-1. Quality grade premiums and discounts per hundredweight of carcass

	Price Level ($/cwt.)				
Grade	Grid 1 Low	Grid 2 Low/Average	Grid 3 Average	Grid 4 Average/High	Grid 5 High
Prime	$7.40	$10.90	$14.40	$17.43	$20.47
Choice	$0.17	$0.85	$1.54	$3.03	$4.52
Choice -	$0.00	$0.00	$0.00	$0.00	$0.00
Select +	($22.84)	($15.94)	($9.05)	($5.12)	($1.20)
Select -	($22.84)	($15.94)	($9.05)	($5.12)	($1.20
Standard +	($29.76)	($22.81)	($15.86)	($11.30)	($6.75)
Standard -	($29.76)	($22.81)	($15.86)	($11.30)	($6.75)

Source: LMIC (2008).
Note: *Choice* = cattle receiving a quality grade in the upper 2/3 Choice. Grid 1 = low grid prices; Grid 2 = Low/Average grid prices; Grid 3 = Average grid prices; Grid 4 = Average/High grid prices; Grid 5 = High grid prices.

Table III-2. Yield grade premiums and discounts per hundredweight of carcass

Grade	Price Level ($/cwt.) Grid 1 Low	Grid 2 Low/Average	Grid 3 Average	Grid 4 Average/High	Grid 5 High
< 2	$3.56	$3.80	$4.05	$4.21	$4.37
≥ 2 : < 2.5	$1.91	$1.97	$2.04	$2.07	$2.10
≥ 2.5 : < 3	$1.09	$1.52	$1.96	$1.98	$2.01
≥ 3 : < 4	($0.19)	($0.15)	($0.12)	($0.60)	($0.00)
≥ 4 : < 5	($17.58)	($16.55)	($15.53)	($13.98)	($12.43)
> 5	($25.82)	($24.21)	($22.61)	($21.77)	($20.93)

Source: LMIC (2008).
Note: Grid 1 = low grid prices; Grid 2 = Low/Average grid prices; Grid 3 = Average grid prices; Grid 4 = Average/High grid prices; Grid 5 = High grid prices.

Table III-3. Hot carcass weight discounts per hundredweight of carcass

Weight (lbs.)	Price Level ($/cwt.) Grid 1 Low	Grid 2 Low/Average	Grid 3 Average	Grid 4 Average/High	Grid 5 High
< 500	($37.56)	($33.69)	($29.82)	($25.43)	($21.05)
≥ 500 : < 550	($29.31)	($26.35)	($23.40)	($21.19)	($18.99)
≥ 550 : < 600	($1.11)	($0.94)	($0.78)	($1.98)	($0.72)
≥ 600 : < 900	($0.00)	($0.00)	($0.00)	($0.00)	($0.00)
≥ 900 : < 950	($0.06)	($0.03)	($0.00)	($0.00)	($0.00)
≥ 950 : < 1000	($7.15)	($4.62)	($2.09)	($1.05)	($0.01)
≥ 1000	($24.57)	($22.93)	($21.29)	($17.08)	($12.87)

Source: LMIC (2008).
Note: Grid 1 = low grid prices; Grid 2 = Low/Average grid prices; Grid 3 = Average grid prices; Grid 4 = Average/High grid prices; Grid 5 = High grid prices.

The net market price was calculated by adding on premiums to the base price for exceptional quality grade and yield grade, and subtracting discounts from the base price for poor quality grade, yield grade, and hot carcass weight. Revenue for each animal was calculated as:

(1) $$\text{Revenue}_i(\$/\text{head}) = \frac{(\text{HCW}_i \times (\text{BP}_i \pm \text{QGpd}_i \pm \text{YGpd}_i - \text{HCWd}_i))}{100}$$

where *i* is a subscript indicating animal identification *i* ε {1,…, 2201};

HCW_i (lbs.) is the hot carcass weight for the i^{th} animal;

BP_i (\$/cwt.) is the market base price for the i^{th} animal;

$QGpd_i$ (\$/cwt.) is the quality grade premium or discount for the i^{th} animal;

$YGpd_i$ (\$/cwt.) is the yield grade premium or discount for the i^{th} animal;

$HCWd_i$ (\$/cwt.) is the hot carcass weight discount for the i^{th} animal.

Estimating Feeder Cattle Purchase Costs

Before cattle are placed into a feedlot, they are purchased as feeder cattle through either private treaty or auction. Prices of feeder cattle depend heavily on weight, where price will steadily decrease as weight increases. In addition, steers normally earn a premium price compared to heifers (Sewell 1993).

To calculate animal purchase cost, real market prices were used for each animal. The market purchase price (P_{0i}) was computed for each animal weight category from a list of 2009 Oklahoma feeder cattle auction market prices. In table III-4, market feeder cattle prices used for this study are reported.

Table III-4. Market purchasing price per hundredweight of feeder calves

Weight (lbs.)	Steers ($/cwt.)	Heifers ($/cwt.)
< 300	$138.00	$116.39
≥ 300 : < 350	$128.42	$111.96
≥ 350 : < 400	$123.62	$107.53
≥ 400 : < 450	$116.07	$103.10
≥ 450 : < 500	$113.81	$100.22
≥ 500 : < 550	$108.37	$100.71
≥ 550 : < 600	$106.86	$99.41
≥ 600 : < 650	$105.09	$99.82
≥ 650 : < 700	$104.66	$98.29
≥ 700 : < 750	$103.47	$97.51
≥ 750 : < 800	$101.57	$93.93
≥ 800 : < 850	$99.17	$93.29
≥ 850 : < 900	$99.19	$90.93
≥ 900 : < 950	$96.47	$88.57
≥ 950 : < 1000	$92.30	$85.37
≥ 1000 : < 1050	$89.80	$82.17
≥ 1050 : < 1100	$86.50	$78.97
≥ 1100 : < 1150	$83.20	$75.77
≥ 1150 : < 1200	$79.90	$72.57
≥ 1200 : < 1250	$76.60	$69.37
≥ 1250 : < 1300	$73.30	$66.17
≥ 1300 : < 1350	$70.00	$62.97

Source: USDA AMS (2009).

Animal purchase cost was determined by taking placement weight (Wt_{0i}) multiplied by P_{0i}, and then dividing by 100 (to adjust for hundredweight). Animal purchase cost was calculated as follows:

(2) $$\text{Purchase Cost}_i(\$/\text{head}) = \frac{(\text{Wt}_{0i} \times \text{P}_{0i})}{100}$$

where i is a subscript indicating animal identification i ε {1,…, 2201};

Wt_{0i} (lbs.) is the weight placed into the feedlot for the i^{th} animal;

P_{0i} ($/cwt.) is the market purchasing price for the i^{th} animal.

Estimating Fed Cattle Costs

The "California Net Energy System" (CNES) was introduced in the 1960's by G.P. Lofgreen and W.N. Garrett and is widely used for estimating net energy and feed requirements for growing and finishing cattle in the feedlot (Greer and Trapp 1999). In 1977, D.G. Fox and J.R. Black adopted the net energy system and included adjustments for factors that affect the net energy requirements of cattle (Brorsen et al. 1983).

For this study, net energy required for growth and maintenance was used to calculate a dry matter (feed) intake equation for growing and finishing cattle as illustrated in "Nutrient Requirements of Beef Cattle - Update 2000." Further, calculating dry matter intake per animal provides a better representation of growth parameters of feedlot cattle as they progress in days-on-feed and daily weight gain. Intuitively, heavier and older cattle will consume more feed to maintain their designated energy levels for growth and maintenance. When cattle consume more feed, the cost of feed is driven upward.

Before calculating dry matter intake, a step was taken to estimate daily live weight of each animal (Lwt_i). Projected weight of each animal for every day in feedlot was calculated as:

(3) $$\mathrm{Lwt}_i(\mathrm{lbs.}) = \mathrm{Wt}_{0i} + \left(\frac{(\mathrm{Wt}_{1i} - \mathrm{Wt}_{0i})}{\mathrm{DOF}_i}\right) \times \mathrm{T}_i \ \forall\ \mathrm{T}_i\ \varepsilon \{1, \ldots, \mathrm{DOF}_i\}$$

where i is a subscript indicating animal identification $i\ \varepsilon\ \{1, \ldots, 2201\}$;

Wt_{1i} (lbs.) is the weight of the i^{th} animal at slaughter;

Wt_{0i} (lbs.) is the placement weight of the i^{th} animal in the feedlot;

DOF_i (days) is days-on-feed for the i^{th} animal;

T_i (days) is a specific day-on-feed for the i^{th} animal in the feedlot.

When calculating dry matter intake, other factors such as empty body (gut) weight, growth hormones, air temperature, and muddy soil have an impact on daily growth and maintenance of feedlot cattle. For example, the variation in weight of digestive tract contents may create problems when predicting live weight gains in cattle (Fox et al. 1976). When calculating dry matter intake, an adjustment factor for empty body weight was included. Using an equation from Fox et al. (1976), empty body weight (EBW_i) of cattle in the feedlot at a given period of time was calculated as:

(4) $$\mathrm{EBW}_i(\mathrm{kg.}) = \frac{\left(1.4\times\left(\frac{\mathrm{HCW}_i}{\mathrm{Wt}_{1i}}\right)\times\left(\frac{\mathrm{Lwt}_i}{2.2046}\right)\right)}{40.2}$$

where i is a subscript indicating animal identification i ε {1,…, 2201};

HCW_i (lbs.) is hot carcass weight for the i^{th} animal;

Wt_{1i} (lbs.) is the weight of the i^{th} animal at slaughter;

Wt_{0i} (lbs.) is the placement weight of the i^{th} animal in the feedlot;

Lwt_i (lbs.) is projected weight for every day in feedlot for the i^{th} animal.

Table III-5. Empty body weight ($BFAF_i$) adjustment factors

EBW_i (kg.)	Empty body weight adjustment factor ($BFAF_i$)
> 0	0.73
< 550	0.73
< 500	0.82
< 450	0.90
< 400	0.97
< 350	1.00

Source: Nutrient Requirements of Beef Cattle (2000).

A growth hormone adjustment was also included in the dry matter intake equation. In this study, those cattle that were not given growth hormones were issued an adjustment factor ($ADTV_i$) of 0.94. Adjustments for air temperature and muddy soil were omitted because this information was not included in the data set. After adjustment factors were issued, dry matter intake (DMI_i) per animal was calculated as:

(5) $$\mathrm{DMI}_i(\mathrm{kg.}) = \frac{\left(\left(\left(\frac{\mathrm{Lwt}_i \times 0.96}{2.2046}\right)^{0.75}\right) \times \left(0.2435 \times \mathrm{NEm} - 0.0466 \times \mathrm{NEm}^2 - 0.0869\right)\right)}{\mathrm{NEm}} \times (\mathrm{BFAF}_i \times \mathrm{ADTV}_i)$$

where i is a subscript indicating animal identification i ε {1,…, 2201};

Lwt_i (lbs.) is an estimation of daily weight for the i^{th} animal;

NEm (Mcal/kg.) is the energy in the diet ration required for maintenance; where $NEm = 1.5$;

$BFAF_i$ is the empty body weight adjustment factor for the i^{th} animal;

$ADTV_i$ is the growth hormone adjustment factor for the i^{th} animal.

After an estimation of dry matter intake was calculated for each animal, the average dry matter intake ($DMIavg_i$) for each animal was computed by using the equation:

(6) $$\mathrm{DMIavg}_i(\mathrm{lbs.}) = \left(\frac{\mathrm{DMI}_i}{\mathrm{DOF}_i}\right) \times 2.2046$$

where i is a subscript indicating animal identification i ε {1,…, 2201};

DMI_i (kg.) is dry matter intake for the i^{th} animal in the feedlot;

DOF_i (days) is days-on-feed for the i^{th} animal.

For this study, steers were assumed to gain 3.75 pounds per day and heifers gained 3.00 pounds per day in the feedlot. Average daily feedlot costs were \$2.96 for steers and \$2.51 for heifers. A yardage fee of \$0.35 was subtracted from the feedlot costs, so average daily feed costs became \$2.61 for steers and \$2.16 for heifers. The denominator of the following equation computes cost of feed per kilogram where DMI_{AVGi} is divided into 2.2046. Using that information, feed cost of gain for steers and heifers were calculated as:

$$(7) \qquad \text{Steer Cost of Gain}_i(\$/\text{head}) = \text{DMI}_i\left(\frac{\$2.61}{\left(\text{DMIavg}_i/_{2.2046}\right)}\right)$$

$$(8) \qquad \text{Heifer Cost of Gain}_i(\$/\text{head}) = \text{DMI}_i\left(\frac{\$2.16}{\left(\text{DMIavg}_i/_{2.2046}\right)}\right)$$

where i is a subscript indicating animal i ε {1,…,2201};

DMI_i (kg.) is dry matter intake for the i^{th} animal in the feedlot;

$DMIavg_i$ (lbs.) is average dry matter intake for the i^{th} animal in the feedlot.

The costs associated with feeding cattle in a feedlot are also affected in other ways. For example, the number of days-on-feed that cattle are in a feedlot will affect yardage fees, interest, and opportunity costs.

Yardage fees include fixed and marginal costs of maintaining feedlot property, buildings, and machinery. As mentioned previously, a yardage fee of \$0.35 per day on feed for each animal was assessed. Yardage fees were calculated as:

$$(9) \qquad \text{Yardage Fee}_i(\$/\text{head}) = 0.35 \times \text{DOF}_i$$

where i is a subscript indicating animal i ε {1,…,2201};

DOF_i (days) is days-on-feed for the i^{th} animal.

Interest on investment is the cost accrued on the initial cost of each animal, feed, and yardage. An interest rate of 7% per day on feed for each animal was assessed. Interest for animals, feed, and yardage was calculated as:

$$(10) \qquad \text{Animal Interest}_i(\$/\text{head}) = \text{Purchase Cost}_i \times \left(\frac{0.07}{365}\right) \times \text{DOF}_i$$

(11) $$\text{Feed Interest}_i(\$/\text{head}) = \left(\frac{\text{Cost of Gain}_i}{2}\right) \times \left(\frac{0.07}{365}\right) \times \text{DOF}_i \quad \forall\ \text{Cost of Gain}_i\ \varepsilon\ \{\text{Steer or Heifer}\}$$

(12) $$\text{Yardage Interest}_i(\$/\text{head}) = \left(\frac{0.35}{2}\right) \times 0.07 \times \text{DOF}_i$$

where i is a subscript indicating animal i ε {1,…,2201};

Purchase Cost$_i$ ($/head) is the feeder cattle purchase cost for the i^{th} animal;

Cost of Gain$_i$ ($/head) is the cost of gain for the i^{th} animal;

DOF$_i$ (days) is days-on-feed for the i^{th} animal.

Opportunity costs associated with keeping cattle in the feedlot for an additional day was calculated as:

(13) $$\text{Opportunity Cost}_i(\$/\text{head}) = \left(\frac{(\text{Revenue}_i + \text{Purchase Cost}_i)}{2}\right) \times \left(\frac{0.07}{2}\right) \times \text{DOF}_i$$

where i is a subscript indicating animal i ε {1,…,2201};

Revenue$_i$ ($/head) is fed cattle revenue for the i^{th} animal;

Purchase Cost$_i$ ($/head) is the feeder cattle purchase cost for the i^{th} animal;

DOF$_i$ (days) is days-on-feed for the i^{th} animal.

Animal purchasing cost, cost of gain, yardage, interest, and opportunity cost were added together to determine the total cost for each animal. Total costs were calculated as:

(14) $$\text{Total Cost}_i(\$/\text{head}) = \text{Purchase Cost}_i + \text{Cost of Gain}_i + \text{Yardage Fee}_i + \text{Interest}_i + \text{Opportunity Cost}_i$$

Estimating Fed Cattle Profits

After costs have been determined, an estimation of fed cattle profit was calculated. Profits were found by subtracting revenue from total cost:

(15) $$\text{Profit}_i(\$/\text{head}) = \text{Revenue}_i - \text{Total Cost}_i.$$

Empirical Models

A regression model was used to estimate the direct effects of Igenity panel scores on fed cattle profit. Mixed linear models were developed to estimate different levels of profit given Igenity panel scores. In the model, profit is a function of Igenity panel scores, days-on-feed, placement age, placement weight, gender. Variables were included to account for potential quadratic impacts of placement weight and polynomial impacts of days-on-feed with profit. Further, dummy variables for sire breed and dam breed were included to determine how the intercept shifts with each breed. Lastly, lot variables were included in the model. Lot was treated as a random effect, so an error term was included to represent the effects of lot.

The regression model was modified to account for several problems. The days-on-feed and placement weight variables were scaled as necessary to reduce ill-conditioned hessian matrices. The profit model was also tested for heteroskedasticity problems. Heteroskedasticity was tested by comparing a restricted and unrestricted model with a likelihood ratio test. Homoskedasticity was rejected and corrected using a White heteroskedasticity consistent estimator (Greene 2000). Finally, a correlation matrix composed of the independent variables showed little evidence of multicollinearity. The profit equation is given as:

$$\begin{aligned} \text{Profit}_i = {} & \alpha_0 + \alpha_1 \text{IG}_{i\text{REA}} + \alpha_2 \text{IG}_{i\text{TEN}} + \alpha_3 \text{IG}_{i\text{MAR}} + \alpha_4 \text{IG}_{i\text{YDG}} \\ & + \alpha_5 \text{IG}_{i\text{ADG}} + \alpha_6 \text{IG}_{i\text{RFI}} + \alpha_7 \text{DOF}_i + \alpha_8 \text{DOF}_i^2 + \alpha_9 \text{DOF}_i^3 \\ & + \alpha_{10} \text{DOF}_i^4 + \alpha_{11} \text{AGE}_{0i} + \alpha_{12} \text{Wt}_{0i} + \alpha_{13} \text{Wt}_{0i}^2 + \alpha_{14} \text{G}_i \\ & + \textstyle\sum_{j=1}^{17} \alpha_{31} \text{SIRE}_{ij} + \sum_{j=1}^{24} \alpha_{55} \text{DAM}_{ij} + \sum_{j=1}^{13} \gamma_{ij} + \varepsilon_i \end{aligned} \tag{16}$$

Previously, it was hypothesized that profit is affected by Igenity panel scores. It was also hypothesized that days-on-feed and placement weight may be affected by Igenity panel scores. Regression models were formulated to test the hypotheses that genetics influence days-on-feed and placement weight. Specifically, mixed linear models were developed to estimate days-on-feed and placement weight given Igenity panel scores. Additional independent variables include placement age and gender (1 = steer; 0 = heifer). Dummy variables for sire breed and dam breed were also included to determine how the intercept shifts with each breed. Lastly, lot variables were included in the model. Lot was treated as a random effect, so an error term was included to represent the effects of lot.

The days-on-feed and placement weight models were tested for heteroskedasticity problems. Heteroskedasticity was tested by comparing a restricted and unrestricted model with a likelihood ratio test. Homoskedasticity was rejected in both equations and was corrected using a White heteroskedasticity consistent estimator (Greene 2000). The equations are given as:

$$\begin{aligned} \text{DOF}_i = {} & \alpha_0 + \alpha_1 \text{IG}_{i\text{REA}} + \alpha_2 \text{IG}_{i\text{TEN}} + \alpha_3 \text{IG}_{i\text{MAR}} + \alpha_4 \text{IG}_{i\text{YDG}} \\ & + \alpha_5 \text{IG}_{i\text{ADG}} + \alpha_6 \text{IG}_{i\text{RFI}} + \alpha_7 \text{AGE}_{0i} + \alpha_8 \text{Wt}_{0i} + \alpha_9 \text{Wt}_{0i}^2 \\ & + \alpha_{10} \text{G}_i + \textstyle\sum_{j=1}^{17} \alpha_{27} \text{SIRE}_{ij} + \sum_{j=1}^{24} \alpha_{51} \text{DAM}_{ij} \\ & + \textstyle\sum_{j=1}^{13} \omega_{ij} + \mu_i \end{aligned} \tag{17}$$

$$
\begin{aligned}
\text{(18)} \quad \mathrm{Wt}_{0i} = {} & \alpha_0 + \alpha_1 \mathrm{IG}_{i\mathrm{REA}} + \alpha_2 \mathrm{IG}_{i\mathrm{TEN}} + \alpha_3 \mathrm{IG}_{i\mathrm{MAR}} + \alpha_4 \mathrm{IG}_{i\mathrm{YDG}} \\
& + \alpha_5 \mathrm{IG}_{i\mathrm{ADG}} + \alpha_6 \mathrm{IG}_{i\mathrm{RFI}} + \alpha_7 \mathrm{AGE}_{0i} + \alpha_8 \mathrm{G}_i \\
& + \textstyle\sum_{j=1}^{17} \alpha_{25} \mathrm{SIRE}_{ij} + \sum_{j=1}^{24} \alpha_{49} \mathrm{DAM}_{ij} + \sum_{j=1}^{13} \eta_{ij} + \upsilon_i
\end{aligned}
$$

Using the empirical models, the marginal impact of the Igenity panel scores on profit was assessed by partially differentiating the profit function. In the derivative, total impact was assessed by including direct and indirect effects on fed cattle profit. Further, marginal impact was assessed by calculating the marginal (single unit increase) change in each Igenity panel score. Via the chain rule, a derivative of profit with respect to the Igenity panels is given as:

$$
\begin{aligned}
\text{(19)} \quad \frac{\partial \pi_i}{\partial \mathrm{IG}_{ij}} = {} & \frac{\partial \pi_i}{\partial \mathrm{IG}_{ij}} + \frac{\partial \pi_i}{\partial \mathrm{DOF}_i} \times \frac{\partial \mathrm{DOF}_i}{\partial \mathrm{IG}_{ij}} + \frac{\partial \pi_i}{\partial \mathrm{DOF}_i^2} \times \frac{\partial DOF_i^2}{\partial \mathrm{DOF}_i} \times \frac{\partial \mathrm{DOF}_i}{\partial \mathrm{IG}_{ij}} \\
& + \frac{\partial \pi_i}{\partial \mathrm{DOF}_i^3} \times \frac{\partial DOF_i^3}{\partial \mathrm{DOF}_i} \times \frac{\partial \mathrm{DOF}_i}{\partial \mathrm{IG}_{ij}} + \frac{\partial \pi_i}{\partial \mathrm{DOF}_i^4} \times \frac{\partial DOF_i^4}{\partial \mathrm{DOF}_i} \times \frac{\partial \mathrm{DOF}_i}{\partial \mathrm{IG}_{ij}} \\
& + \frac{\partial \pi_i}{\partial \mathrm{Wt}_{0i}} \times \frac{\partial \mathrm{Wt}_{0i}}{\partial \mathrm{IG}_{ij}} + \frac{\partial \pi_i}{\partial \mathrm{Wt}_{0i}^2} \times \frac{\partial \mathrm{Wt}_{0i}^2}{\partial \mathrm{Wt}_{0i}} \times \frac{\partial \mathrm{Wt}_{0i}}{\partial \mathrm{IG}_{ij}}.
\end{aligned}
$$

Data

A data set for 2201 steers and heifers was provided by Igenity. Cattle were sourced from several locations in the United States including Georgia, Iowa, Kentucky, Missouri, Mississippi, South Carolina, Tennessee and Virginia across herds of mostly *Bos taurus* cattle. Cattle were finished at Nebraska and Kansas feedlots.

It is not known how the cattle represented by this data set were selected and managed. No information was provided on the quality standard of cattle coming into the feedlots. Further, details of the data collection process were not provided. Data such as days-on-feed and placement weight were recorded by personnel working for Igenity.

Therefore inferences in this study were based solely on data provided and not direct observation.

Specific cattle measurements in the data set including placement age, placement weight, days on feed, finished live weight, hot carcass weight, calculated yield grade, and gender are presented in table III-6. Summary statistics including the average, median, maximum, minimum, standard deviation, and number of observations are illustrated.

Igenity panel summary statistics are also presented in table III-6. The data set included Igenity panel scores for ribeye, tenderness, marbling, yield grade, average daily gain, and residual feed intake. The Igenity panel scores were given on a scale of one to ten, where a score of ten is preferred for all panels except yield grade and residual feed intake. For the yield grade and residual feed intake panels, a score of one is most desirable.

Additionally, cattle breeds in the data set were categorized by sire and dam. Sires were categorized into 17 pure and cross breeds, while dams were categorized into 24 pure and cross breeds. Further, cattle were also categorized by lot size. A total of 13 cattle lots were categorized into specific groups.

Table III-6. Fed cattle measurements and Igenity panel score summary statistics

	Average	Median	Maximum	Minimum	SD	N
AGE_{0i} *(days)*	305	290	669	149	89	2167
Wt_{0i} *(lbs.)*	734	738	1290	294	160	2201
DOF_i *(days)*	168	166	256	106	32	2191
HCW_i *(lbs.)*	732	725	1015	513	77	2177
FLW_i *(lbs.)*	1182	1175	1614	566	125	2184
Calc. YG_i	3.0	3.0	4.9	0.3	0.6	2170
Steer						1663
Heifer						538
IG_{iREA}	4.8	5.0	9.0	1.0	1.1	2201
IG_{iTEN}	5.8	6.0	10.0	1.0	2.0	1981
IG_{iMAR}	6.6	7.0	10.0	3.0	1.2	2201
IG_{iYDG}	6.2	6.0	10.0	2.0	1.2	2199
IG_{iADG}	5.7	6.0	8.0	1.0	1.0	2199
IG_{iRFI}	6.1	6.0	10.0	2.0	1.2	2198

Note: AGE_{0i} = Age placed in feedlot for the i^{th} animal; Wt_{0i} = Weight placed into the feedlot for the i^{th} animal; DOF_i = Days-on-feed for the i^{th} animal; HCW_i = Hot carcass weight for the i^{th} animal; FLW_i = Final live weight for the i^{th} animal; *Calc.* YG_i = Calculated yield grade for the i^{th} animal; IG_{iREA} = Igenity panel ribeye area score for the i^{th} animal; IG_{iTEN} = Igenity panel tenderness score for the i^{th} animal; IG_{iMAR} = Igenity panel marbling score for the i^{th} animal; IG_{iYDG} = Igenity panel yield grade score for the i^{th} animal; IG_{iADG} = Igenity panel average daily gain score for i^{th} animal; IG_{iRFI} = Igenity panel residual feed intake score for i^{th} animal.

CHAPTER IV

RESULTS

In the previous chapter, a model was specified to estimate fed cattle profit as a function of Igenity panel scores. Feedlot cattle days-on-feed and placement weight models were also specified as functions of Igenity panel scores. A system of equations was presented to evaluate the direct and indirect effects of Igenity panel scores on fed cattle profit. Using data from Igenity, mixed linear models were developed using the SAS – PROC MIXED procedure. Also, each equation was estimated using restricted maximum likelihood (REML) estimations.

Regression Results of Direct Effects on Profit

A total of 15 regressions were estimated using five grid pricing scenarios paired with three fed cattle base prices. The regression results are reported in tables IV-1 to IV-5. Estimated coefficients and standard errors for the independent variables are also reported. Finally, the estimations for sire breeds and dam breeds are reported in appendix tables 1 and 2.

Table IV-1. Regression results of direct effects for grid 1 (low grid prices)

Explanatory Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
Intercept	-439.44	-515.44	-591.82
	(1097.71)	(1111.25)	(1125.07)
IG_{REA}	0.08	0.06	0.04
	(2.29)	(2.32)	(2.35)
IG_{TEN}	-0.83	-0.84	-0.85
	(1.20)	(1.22)	(1.23)
IG_{MAR}	10.55*	10.57*	10.59*
	(2.35)	(2.38)	(2.41)
IG_{YDG}	1.84	1.88	1.92
	(2.19)	(2.22)	(2.25)
IG_{ADG}	6.67**	6.92**	7.17**
	(2.75)	(2.79)	(2.82)
IG_{RFI}	0.61	0.60	0.60
	(2.10)	(2.12)	(2.15)
DOF (100 days)	8.11	10.08	12.07
	(2626.77)	(2659.75)	(2693.40)
DOF^2 *(100 days)*^{2}	-0.06	-0.07	-0.09
	(2323.63)	(2353.32)	(2383.60)
DOF^3 *(100 days)*^{3}	1.55E-04	2.12E-04	2.70E-04
	(899.42)	(911.10)	(923.01)
DOF^4 *(100 days)*^{4}	-1.64E-07	-2.42E-07	-3.19E-07
	(128.41)	(130.10)	(131.83)
AGE_0 *(days)*	-0.05	-0.05	-0.06
	(0.07)	(0.07)	(0.07)
Wt_0 *(100 lbs.)*	-0.86*	-0.84*	-0.82*
	(14.85)	(15.04)	(15.24)
Wt_0^2 *(100 lbs.)*^{2}	6.27E-04*	6.33E-04*	6.38E-04*
	(0.93)	(0.95)	(0.96)
G	22.97*	21.46*	19.95*
	(6.78)	(6.88)	(6.97)

*Significant at $p \leq 0.01$.
**Significant at $p \leq 0.05$.
***Significant at $p \leq 0.10$.
Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score; *DOF* = Days-on-feed; DOF^2 = Days-on-feed squared; DOF^3 = Days-on-feed cubed; DOF^4 = Days-on-feed to the fourth power; AGE_0 = Age placed in feedlot; Wt_0 = Weight placed into the feedlot; Wt_0^2 = Weight placed into the feedlot squared; *G* = Dummy variable for gender (1 = steer; 0 = heifer).

Table IV-2. Regression results of direct effects for grid 2 (low/average grid prices)

Explanatory Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
Intercept	-753.21	-834.25	-915.55
	(924.01)	(939.59)	(955.43)
IG_{REA}	0.34	0.32	0.30
	(1.93)	(1.96)	(1.99)
IG_{TEN}	-0.68	-0.69	-0.71
	(1.01)	(1.03)	(1.05)
IG_{MAR}	7.24*	7.26*	7.27*
	(1.98)	(2.01)	(2.05)
IG_{YDG}	1.38	1.42	1.45
	(1.85)	(1.88)	(1.91)
IG_{ADG}	6.36*	6.61*	6.86*
	(2.32)	(2.36)	(2.40)
IG_{RFI}	0.32	0.31	0.31
	(1.76)	(1.79)	(1.83)
DOF (100 days)	18.24	20.34	22.44
	(2217.73)	(2255.65)	(2294.19)
DOF^2 *(100 days)*^{2}	-0.15	-0.16	-0.18
	(1967.76)	(2001.86)	(2036.51)
DOF^3 *(100 days)*^{3}	4.91E-04	5.53E-04	6.14E-04
	(763.93)	(777.33)	(790.95)
DOF^4 *(100 days)*^{4}	-6.30E-07	-7.12E-07	-7.95E-07
	(109.37)	(111.31)	(113.28)
AGE_0 *(days)*	-0.06	-0.06	-0.07
	(0.06)	(0.06)	(0.06)
Wt_0 *(100 lbs.)*	-0.92*	-0.90*	-0.88*
	(12.59)	(12.82)	(13.05)
Wt_0^2 *(100 lbs.)*^{2}	6.60E-04*	6.65E-04*	6.70E-04*
	(0.79)	(0.80)	(0.81)
G	15.51*	14.00*	12.48**
	(5.77)	(5.87)	(5.98)

*Significant at $p \leq 0.01$.
**Significant at $p \leq 0.05$.
***Significant at $p \leq 0.10$.
Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score; *DOF* = Days-on-feed; DOF^2 = Days-on-feed squared; DOF^3 = Days-on-feed cubed; DOF^4 = Days-on-feed to the fourth power; AGE_0 = Age placed in feedlot; Wt_0 = Weight placed into the feedlot; Wt_0^2 = Weight placed into the feedlot squared; *G* = Dummy variable for gender (1 = steer; 0 = heifer).

Table IV-3. Regression results of direct effects for grid 3 (average grid prices)

Explanatory Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
Intercept	-1117.65	-1201.58	-1285.40
	(785.43)	(803.24)	(821.28)
IG_{REA}	0.59	0.56	0.54
	(1.64)	(1.68)	(1.72)
IG_{TEN}	-0.50	-0.51	-0.52
	(0.86)	(0.88)	(0.90)
IG_{MAR}	3.94**	3.95**	3.97**
	(1.68)	(1.72)	(1.76)
IG_{YDG}	0.85	0.89	0.93
	(1.57)	(1.61)	(1.65)
IG_{ADG}	6.01*	6.26*	6.51*
	(1.98)	(2.02)	(2.07)
IG_{RFI}	0.03	0.03	0.02
	(1.50)	(1.54)	(1.57)
DOF (100 days)	29.62	31.78	33.93***
	(1892.82)	(1936.09)	(1979.88)
DOF^2 *(100 days)*^{2}	-0.25	-0.26	-0.28
	(1686.34)	(1725.17)	(1764.45)
DOF^3 *(100 days)*^{3}	8.67E-04	9.31E-04	9.94E-04
	(657.24)	(672.48)	(687.88)
DOF^4 *(100 days)*^{4}	-1.15E-06	-1.24E-06	-1.32E-06
	(94.44)	(96.64)	(98.87)
AGE_0 *(days)*	-0.07	-0.08	-0.08
	(0.05)	(0.05)	(0.05)
Wt_0 *(100 lbs.)*	-0.98*	-0.96*	-0.94*
	(10.81)	(11.07)	(11.33)
Wt_0^2 *(100 lbs.)*^{2}	6.95E-04*	7.00E-04*	7.05E-04*
	(0.67)	(0.68)	(0.70)
G	8.08	6.58	5.07
	(4.97)	(5.09)	(5.21)

*Significant at $p \leq 0.01$.

**Significant at $p \leq 0.05$.

***Significant at $p \leq 0.10$.

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score; *DOF* = Days-on-feed; DOF^2 = Days-on-feed squared; DOF^3 = Days-on-feed cubed; DOF^4 = Days-on-feed to the fourth power; AGE_0 = Age placed in feedlot; Wt_0 = Weight placed into the feedlot; Wt_0^2 = Weight placed into the feedlot squared; *G* = Dummy variable for gender (1 = steer; 0 = heifer).

Table IV-4. Regression results of direct effects for grid 4 (average/high grid prices)

Explanatory Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
Intercept	-1306.06***	-1390.07***	-1473.27***
	(726.02)	(744.99)	(764.19)
IG_{REA}	0.67	0.64	0.62
	(1.52)	(1.56)	(1.60)
IG_{TEN}	-0.33	-0.34	-0.35
	(0.80)	(0.82)	(0.84)
IG_{MAR}	2.17	2.18	2.20
	(1.56)	(1.60)	(1.64)
IG_{YDG}	0.62	0.65	0.69
	(1.46)	(1.50)	(1.54)
IG_{ADG}	5.68*	5.94*	6.20*
	(1.83)	(1.88)	(1.93)
IG_{RFI}	-0.14	-0.14	-0.14
	(1.39)	(1.43)	(1.46)
DOF (100 days)	35.86**	38.01**	40.13**
	(1754.87)	(1800.87)	(1847.35)
DOF^2 *(100 days)*^{2}	-0.30***	-0.32**	-0.34**
	(1568.04)	(1609.25)	(1650.86)
DOF^3 *(100 days)*^{3}	1.08E-03***	1.15E-03***	1.21E-03***
	(612.85)	(628.99)	(645.27)
DOF^4 *(100 days)*^{4}	-1.46E-06***	-1.54E-06***	-1.63E-06***
	(88.29)	(90.62)	(92.96)
AGE_0 *(days)*	-0.07	-0.07	-0.08
	(0.04)	(0.05)	(0.05)
Wt_0 *(100 lbs.)*	-1.03*	-1.01*	-0.99*
	(10.07)	(10.34)	(10.61)
Wt_0^2 *(100 lbs.)*^{2}	7.26E-04*	7.30E-04*	7.34E-04*
	(0.62)	(0.64)	(0.65)
G	4.40	2.89	1.39
	(4.64)	(4.77)	(4.89)

*Significant at $p \leq 0.01$.

**Significant at $p \leq 0.05$.

***Significant at $p \leq 0.10$.

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score; *DOF* = Days-on-feed; DOF^2 = Days-on-feed squared; DOF^3 = Days-on-feed cubed; DOF^4 = Days-on-feed to the fourth power; AGE_0 = Age placed in feedlot; Wt_0 = Weight placed into the feedlot; Wt_0^2 = Weight placed into the feedlot squared; *G* = Dummy variable for gender (1 = steer; 0 = heifer).

Table IV-5. Regression results of direct effects for grid 5 (high grid prices)

Explanatory Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
Intercept	-1513.31**	-1596.04**	-1678.27**
	(697.80)	(717.49)	(737.34)
IG_{REA}	0.49	0.47	0.45
	(1.47)	(1.51)	(1.55)
IG_{TEN}	-0.15	-0.16	-0.17
	(0.77)	(0.79)	(0.81)
IG_{MAR}	0.57	0.58	0.60
	(1.50)	(1.54)	(1.58)
IG_{YDG}	0.43	0.46	0.50
	(1.41)	(1.45)	(1.49)
IG_{ADG}	5.75*	6.01*	6.26*
	(1.77)	(1.82)	(1.87)
IG_{RFI}	-0.21	-0.22	-0.22
	(1.34)	(1.38)	(1.42)
DOF (100 days)	41.99**	44.10**	46.20*
	(1689.98)	(1737.63)	(1785.65)
DOF^2 *(100 days)*^{2}	-0.35**	-0.37**	-0.39**
	(1512.97)	(1555.59)	(1598.52)
DOF^3 *(100 days)*^{3}	1.29E-03**	1.35E-03**	1.41E-03**
	(592.39)	(609.06)	(625.84)
DOF^4 *(100 days)*^{4}	-1.74E-06**	-1.82E-06**	-1.90E-06**
	(85.48)	(87.88)	(90.30)
AGE_0 *(days)*	-0.07***	-0.08***	-0.08***
	(0.04)	(0.04)	(0.05)
Wt_0 *(100 lbs.)*	-1.06*	-1.04*	-1.02*
	(9.73)	(10.01)	(10.29)
Wt_0^2 *(100 lbs.)*^{2}	7.48E-04*	7.51E-04*	7.55E-04*
	(0.60)	(0.61)	(0.63)
G	0.71	-0.80	-2.30
	(4.49)	(4.62)	(4.75)

*Significant at $p \leq 0.01$.
**Significant at $p \leq 0.05$.
***Significant at $p \leq 0.10$.
Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score; *DOF* = Days-on-feed; DOF^2 = Days-on-feed squared; DOF^3 = Days-on-feed cubed; DOF^4 = Days-on-feed to the fourth power; AGE_0 = Age placed in feedlot; Wt_0 = Weight placed into the feedlot; Wt_0^2 = Weight placed into the feedlot squared; *G* = Dummy variable for gender (1 = steer; 0 = heifer).

The results indicate that few of the Igenity panel scores were significant in the profit equations. In all of the profit estimations, the average daily gain panel (IG_{ADG}) was significant (p = ≤ 0.01) and had a positive sign. As IG_{ADG} increased in value on a scale of 1 to 10, fed cattle profits increased. In addition, the marbling panel (IG_{MAR}) was statistically significant (p = ≤ 0.05) at all base prices in grid 1 (low grid prices), grid 2 (low/average grid prices), and grid 3 (average grid prices). IG_{MAR} became insignificant when grid prices changed to grid 4 (average/high grid prices) and grid 5 (high grid prices). The positive sign for IG_{MAR} indicated that fed cattle profits increased for every additional unit increase on a scale of 1 to 10. Lastly, the Igenity variables including ribeye area (IG_{REA}), tenderness (IG_{TEN}), yield grade (IG_{YDG}), and residual feed intake (IG_{RFI}) were not significant in any of the profit equations. Out of all of the insignificant Igenity variables, IG_{REA} and IG_{YDG} had positive signs, while IG_{TEN} had a negative sign. The IG_{RFI} variable changed in sign from negative to positive as grid prices increased, but was not significant.

To further estimate the joint significance of the Igenity panel variables, a log likelihood test was conducted between unrestricted and restricted models. The test indicated that the Igenity panels were jointly significant in the profit equations. While few of the Igenity panel variables were independently significant, when jointly considered, they significantly influenced profit.

Other variables such as placement weight (Wt_0, and Wt_0^2) were significant ($p \leq 0.01$) with fed cattle profit under each price scenario. Furthermore, days-on-feed (DOF, DOF^2, DOF^3, DOF^4) variables were insignificant under all base prices in grid 1 (low grid prices), grid 2 (low/average grid prices), grid 3 (average grid prices). The days-on-feed

(DOF, DOF^2, DOF^3, DOF^4) variables became statistically significant ($p \leq 0.10$) under base prices in grid 4 (average/high grid prices) and grid 5 (high grid prices).

Figures IV-1 and IV-2 both illustrate why a quadratic term for Wt_0 and a fourth-order polynomial for *DOF* were used in the profit equations. In figure IV-1, profits are maximized when cattle are fed for 126 days (holding all other independent variables at their means). The figure also exemplifies why the fourth-order polynomial days-on-feed (*DOF*) variable was needed in the profit equations. Here, profits increase with days-on-feed, reach a maximum, and decrease. Compared to a quadratic shape, this curve is flatter at the right of the peak and non-symmetric. This trend suggests that as days-on-feed increases, yield grade and hot carcass weight are earning price grid discounts at 126 days-on-feed, driving fed cattle profits downward.

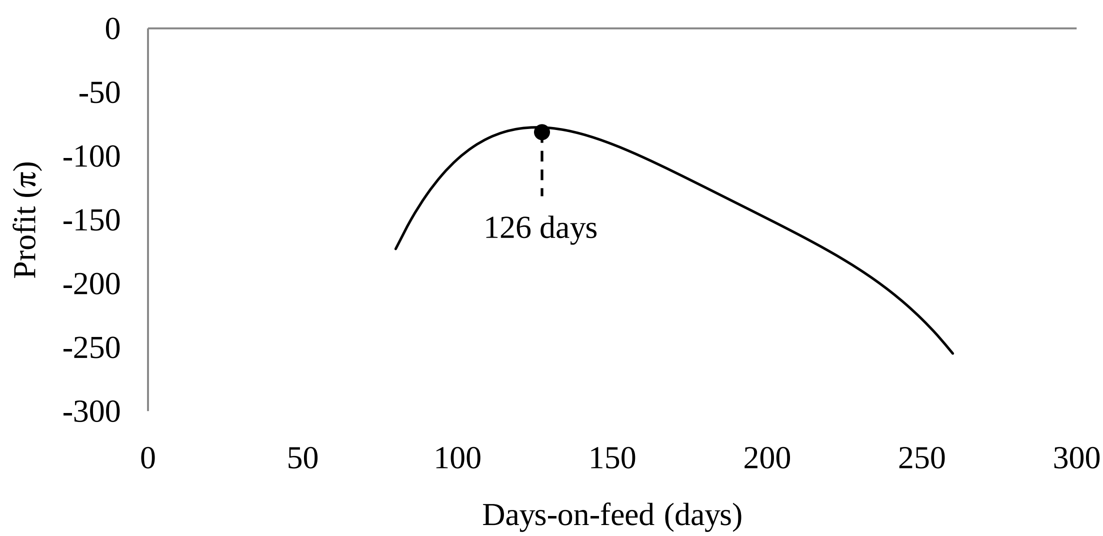

Figure IV-1. Profit maximizing days-on-feed for grid 3 (average grid prices) and $1.45 per lb. base price

In figure IV-2, profits are minimized when cattle are placed in the feedlot at 685 lbs. (holding all other independent variables at their means). Additionally, the graph exemplifies why the quadratic placement weight (Wt_0) variable was needed in the profit equation. Here, profits decrease as placement weight reaches 685 lbs., reach a minimum, and increase. Reasoning behind this trend suggests that as placement weight increases, days-on-feed is reduced, therefore reducing fed cattle cost of gain.

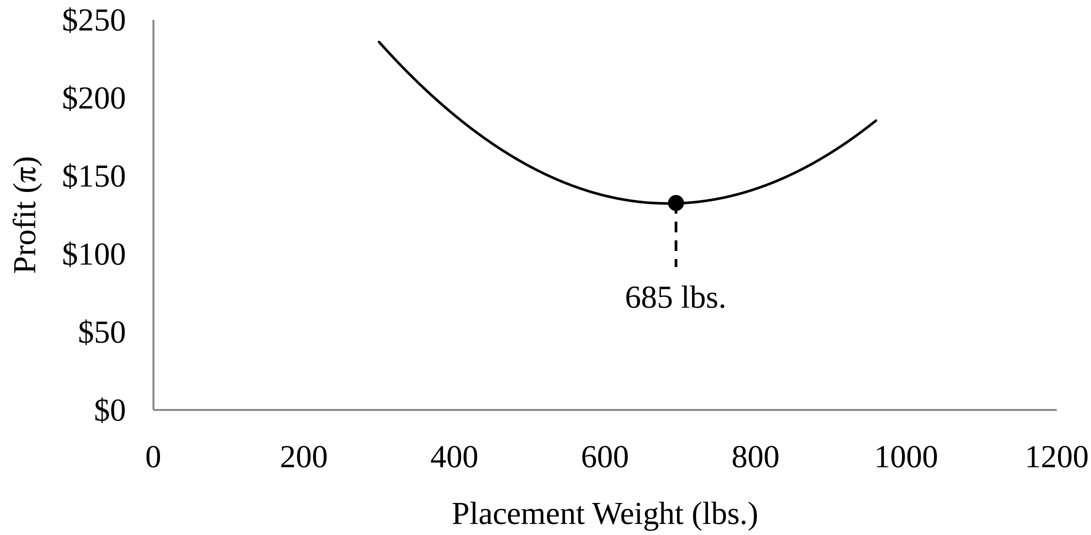

Figure IV-2. Profit minimizing placement weight for grid 3 (average grid prices) and $1.45 per lb. base price

Placement age (AGE_0) was significant ($p \leq 0.01$) across all pricing scenarios. Further, dummy variable gender (*G*) proved to be significant ($p \leq 0.05$) in grids 1 (low grid prices) and 2 (low/average grid prices), where steers were earning positive profits. The dummy variable gender (*G*) became insignificant in the remaining grid pricing scenarios.

Regression Results of Indirect Effects on Profit

As previously mentioned, feedlot cattle days-on-feed and placement weight may also be affected by Igenity panel scores. Mixed linear models were used to test the hypotheses that genetics influence days-on-feed and placement weight. Each model was estimated using the restricted maximum likelihood (REML) method.

Days-on-feed (DOF)

The regression results for days-on-feed are presented in table IV-6. The results indicate that Igenity panel variables IG_{YDG} and IG_{RFI} were significant ($p \leq 0.10$) in the days-on-feed equation. The sign for IG_{YDG} was positive and the sign for IG_{RFI} was negative. Other Igenity panel variables including IG_{REA}, IG_{TEN}, IG_{MAR}, and IG_{ADG}, were not significant in the days-on-feed equation. Out of the insignificant Igenity panel variables, IG_{REA} had a positive sign and IG_{TEN}, IG_{MAR}, and IG_{ADG} each had negative signs.

Although IG_{RFI} was significant and IG_{ADG} was insignificant, the negative signs for both variables were expected. The IG_{RFI} marker panel describes how much feed an animal will consume for maintenance and growth. The IG_{ADG} marker panel provides information on cattle that have the potential of achieving high average daily gain. The negative sign suggested that as both panel scores increase on a scale from 1 to 10, days-on-feed will decrease. These results are intuitive with the fact that cattle having a high Igenity score in residual feed intake and average daily gain will take less time to feed to a finishing weight.

Other independent variables such as placement age, placement weight, and gender all proved to be significant ($p \leq 0.01$) in the days-on-feed equation. The coefficient for placement age was negative. Intuitively, older and slower growing cattle could have taken longer to feed to a finishing weight. The variable for placement weight had a convex (u-shaped) curve, where placement weight was minimized. Although gender was significant, it did not influence much change in days-on-feed. Finally, the estimations for sire breeds and dam breeds are reported in appendix tables 1 and 2.

Placement Weight (Wt_0)

The regression results for placement weight are also presented in table IV-6. The results indicate that IG_{REA}, IG_{TEN}, IG_{ADG} are the only Igenity panel variables that are significant ($p \leq 0.10$) in the placement weight equation. The signs for IG_{REA} and IG_{TEN} were positive, which indicates that as the panel score increases on a scale from 1 to 10, placement weight will increase. Additionally, the sign for IG_{ADG} was negative, which indicates that as the panel score increases on a scale from 1 to 10, placement weight will decrease. This result is intuitive with the fact that cattle that gain weight faster are placed into the feedlot at a lighter weight (Mark et al. 1999).

Other independent variables such as placement age and gender proved to be significant ($p \leq 0.05$) in the placement weight equation. Placement age had a positive sign and gender had a negative sign, which were both expected. Lastly, the results for sire breeds and dam breeds are reported in appendices 1 and 2.

Table IV-6. Regression results for DOF and Wt_0 as dependent variables

Explanatory Variables	Dependent Variables	
	DOF (Std. Error)	Wt_0 (Std. Error)
Intercept	1.93*	4.39*
	(0.12)	(0.56)
IG_{REA}	4.77E-03	0.03***
	(-3.23E-03)	(0.02)
IG_{TEN}	-7.00E-04	0.02***
	(-1.70E-03)	(0.01)
IG_{MAR}	-3.50E-03	0.01
	(-3.32E-03)	(0.02)
IG_{YDG}	0.01***	-1.15E-03
	(-3.08E-03)	(0.02)
IG_{ADG}	-4.25E-03	-0.05*
	(-3.89E-03)	(0.02)
IG_{RFI}	-0.01***	-0.02
	(-2.95E-03)	(0.02)
AGE_0 *(days)*	44.10*	4.77E-03**
	(1737.63)	(5.42E-04)
Wt_0 *(lbs.)*	-0.37*	
	(1555.59)	
Wt_0^2 *(lbs.)*	1.35E-03*	
	(609.06)	
G	-1.82E-06*	-0.66*
	(87.88)	(0.05)

*Significant at $p \leq 0.01$.
**Significant at $p \leq 0.05$.
***Significant at $p \leq 0.10$.
Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score; AGE_0 = Age placed in feedlot; Wt_0 = Weight placed into the feedlot; WT_0^2 = Weight placed into the feedlot squared; *G* = Dummy variable for gender (1 = steer; 0 = heifer).

Total Marginal Impacts on Profit

The total marginal impact of the Igenity panel scores on fed cattle profit was estimated by differentiating the profit function. To reiterate the estimation, total impact was assessed by including direct and indirect effects on fed cattle profit. Marginal impact was assessed by calculating the marginal (single unit increase) change in each Igenity panel score. Via the chain rule, a derivative of profit with respect to each Igenity panel was estimated across the five grid pricing scenarios and three fed cattle base prices. The results of the estimations are presented in tables IV-7 through IV-11. Marginal profit estimations are reported in dollars per head.

In the estimations, several Igenity panel variables were higher in value when compared to the others. For example, IG_{MAR} and IG_{ADG} had positive signs and were gaining considerably higher profits for each additional unit increase on a scale of 1 to 10. On the other hand, the Igenity variables IG_{YDG}, IG_{REA}, IG_{TEN}, and IG_{RFI} were not as high in profit and they were depressed to lower values. The signs for IG_{YDG} and IG_{REA} were positive and the sign for IG_{TEN} was negative. Sign fluctuations occurred with the IG_{RFI} variable when estimations in grid 3 (average grid prices) crossed threshold into grid 4 (average/high grid prices).

The sign for IG_{YDG} was unexpected. Intuitively, IG_{YDG} should have had a negative sign, where fed cattle profit is decreasing for each additional increase in score. Instead, the IG_{YDG} variable proved to have a positive relationship with each additional increase in the panel score. Although IG_{YDG} was counterintuitive, there is the possibility that some SNPs are shared with other panels such as marbling and average daily gain. This sharing of SNPs could explain the positive sign.

Table IV-7. Total marginal effects for grid 1 (low grid prices)

Igenity Panel Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
IG_{REA}	$0.93	$0.97	$1.16
IG_{TEN}	-$0.82	-$0.84	-$0.85
IG_{MAR}	$10.56	$10.57	$10.59
IG_{YDG}	$1.84	$1.88	$1.92
IG_{ADG}	$6.67	$6.92	$7.17
IG_{RFI}	$0.61	$0.61	$0.61

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score.

Table IV-8. Total marginal effects for grid 2 (low/average grid prices)

Igenity Panel Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
IG_{REA}	$0.34	$0.32	$0.30
IG_{TEN}	-$0.68	-$0.69	-$0.70
IG_{MAR}	$7.24	$7.26	$7.28
IG_{YDG}	$1.37	$1.41	$1.45
IG_{ADG}	$6.36	$6.61	$6.86
IG_{RFI}	$0.32	$0.32	$0.31

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score.

Table IV-9. Total marginal effects for grid 3 (average grid prices)

Igenity Panel Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
IG_{REA}	$0.58	$0.56	$0.54
IG_{TEN}	-$0.50	-$0.51	-$0.52
IG_{MAR}	$3.94	$3.96	$3.97
IG_{YDG}	$0.85	$0.88	$0.92
IG_{ADG}	$6.01	$6.26	$6.51
IG_{RFI}	$0.04	$0.03	$0.03

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score.

Table IV-10. Total marginal effects for grid 4 (average/high grid prices)

Igenity Panel Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
IG_{REA}	$0.66	$0.64	$0.62
IG_{TEN}	-$0.32	-$0.33	-$0.34
IG_{MAR}	$2.17	$2.19	$2.20
IG_{YDG}	$0.61	$0.65	$0.69
IG_{ADG}	$5.69	$5.94	$6.20
IG_{RFI}	-$0.13	-$0.14	-$0.14

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score.

Table IV-11. Total marginal effects for grid 5 (high grid prices)

Igenity Panel Variables	Base Price $1.40 per lb. (Std. Error)	Base Price $1.45 per lb. (Std. Error)	Base Price $1.50 per lb. (Std. Error)
IG_{REA}	$0.49	$0.46	$0.44
IG_{TEN}	-$0.15	-$0.16	-$0.17
IG_{MAR}	$0.57	$0.59	$0.60
IG_{YDG}	$0.42	$0.46	$0.49
IG_{ADG}	$5.75	$6.01	$6.26
IG_{RFI}	-$0.21	-$0.21	-$0.21

Note: IG_{REA} = Igenity panel ribeye area score; IG_{TEN} = Igenity panel tenderness score; IG_{MAR} = Igenity panel marbling score; IG_{YDG} = Igenity panel yield grade score; IG_{ADG} = Igenity panel average daily gain score; IG_{RFI} = Igenity panel residual feed intake score.

CHAPTER V

CONCLUSIONS

This chapter summarizes the problem addressed, the objectives, the methodology, and the results. The implications, limitations, and direction for future research are also presented.

Summary of Problem

The investigation into the economics of commercial genetics testing in cattle is relatively new. Only a few studies have estimated the economics of commercial genetic testing in beef cattle (e.g., DeVuyst et al. 2007; Lusk 2007). Lusk (2007) analyzed one SNP and a microsatellite on the leptin gene in a sample of commercial feedlot cattle. DeVuyst et al (2007) also investigated the influence of a SNP on cow/calf profitability. Although their analyses utilized the best genetic information available at the time, these studies only consider the economic implications from one or two genetic markers in their results.

Genetic marker panels, such as the Merial Igenity panels, have not been previously investigated using economic analysis. There is uncertainty among feedlot cattle operators as to the economic gain they will receive from testing their cattle with a commercial genetics panel.

Therefore, there is a need to provide the beef industry with economic information pertaining to the validity of the genetic testing services and the effect on fed cattle profitability.

Summary of Objectives

The main objective of this study was to determine the economic value of genotypic information from the Merial Igenity panel for fed cattle. The specific objectives were to: (1) empirically model fed cattle profits; (2) determine direct and indirect effects from the Igenity beef panels on fed cattle profits; (3) determine the total marginal effects of Igenity panel scores on fed cattle profits; (4) determine the sensitivity of the model by varying fed cattle grid prices and market base prices.

Summary of Methodology

To fulfill the objectives and test the hypotheses of this research, a data set was provided by Igenity. Grid prices were paired with market base prices to determine 15 revenue scenarios for each head of cattle. Feedlot costs were subtracted from revenues to determine fed cattle profits. Regression models were used to estimate profit for each head of cattle given Igenity panel scores. An economic analysis utilizing mixed linear modeling was conducted to evaluate the Igenity panel's direct and indirect effects on fed cattle profits. Each model was estimated using the restricted maximum likelihood (REML) method. Statistical analysis using Statistical Analysis Software (SAS) was performed by examining the p-values of the results. The total marginal effects of the Igenity panel scores on profit were estimated by differentiating the profit function.

Summary of Results

Direct Effects on Fed Cattle Profits

The profit equation estimations revealed that Igenity panel scores including average daily gain (IG_{ADG}) and marbling (IG_{MAR}) have a significant impact on fed cattle profitability. In all of the estimations, IG_{ADG} was significant ($p = \leq 0.01$). In addition, IG_{MAR} was statistically significant ($p = \leq 0.05$) at all base prices in grid 1 (low grid prices), grid 2 (low/average grid prices), and grid 3 (average grid prices). The positive signs for IG_{ADG} and IG_{MAR} were expected. Igenity panel variables including IG_{REA}, IG_{TEN}, IG_{YDG}, and IG_{RFI} were not significant in any of the profit equations. Out of the insignificant Igenity variables, IG_{REA} and IG_{YDG} had positive signs, while IG_{TEN} had a negative sign. The IG_{RFI} variable changed in sign from negative to positive as grid prices increased.

A log likelihood test was conducted between unrestricted and restricted models to determine joint significance of the Igenity panels variables. The test indicated that the Igenity panel variables were jointly significant. While few of the Igenity panel variables are independently significant, when jointly considered, they significantly influenced fed cattle profit.

Indirect Effects on Fed Cattle Profits

The indirect effect results indicated that Igenity panel variables IG_{YDG} and IG_{RFI} were significant ($p \leq 0.10$), while IG_{REA}, IG_{TEN}, IG_{MAR}, and IG_{ADG} were not significant in the days-on-feed equation. Other independent variables such as placement age, placement weight, and gender all proved to be significant ($p \leq 0.01$) in the days-on-feed equation as well. In addition, IG_{REA}, IG_{TEN}, IG_{ADG} are the only Igenity panel variables that are significant ($p \leq 0.10$) in the placement weight equation. Other independent variables such as placement age and gender also proved to be significant ($p \leq 0.05$).

Total Marginal Impacts on Fed Cattle Profits

In the marginal profit estimations, Igenity panel variables for marbling (IG_{MAR}) and average daily gain (IG_{ADG}) were gaining considerably higher profits for each additional unit increase on a scale of 1 to 10. Other Igenity panel variables, such as IG_{YDG}, IG_{REA}, IG_{TEN}, and IG_{RFI} were not as high in the profit equation, having lower marginal values in total effect.

Implications

The Merial Igenity panels have an effect on fed cattle profitability. Specifically, the Igenity panel scores for marbling (IG_{MAR}) and average daily gain (IG_{ADG}) had a significant and positive impact in most of the profit equations. The marginal estimations further illustrated the impact that IG_{MAR} and IG_{ADG} had on fed cattle profits. At the high end, cattle operators could expect to gain $10.59 for each additional increase in IG_{MAR} score. With average grid prices, $3.96 in marginal profit could be earned. Cattle operators could also assume to gain a high value of $7.17 for each additional unit increase in IG_{ADG} score. With average grid prices, $6.26 in marginal profit could be earned.

Because the Igenity panels for marbling and average daily gain provide greater value to feedlot operators, new selection and management strategies could arise. For example, if information is available, operators could initially select cattle having high IG_{MAR} scores and feed them out together accordingly. Similarly, cattle having high IG_{ADG} scores could be penned and fed accordingly. This leads to new penning and grouping strategies that could be implemented to effectively manage cattle based on Igenity panel scores for marbling and average daily gain.

Other Igenity panel information such as yield grade (IG_{YDG}), ribeye area (IG_{REA}), tenderness (IG_{TEN}), and residual feed intake (IG_{RFI}) should not be ignored. Although, their marginal profitability was lower and signs were erratic, they require more analysis to understand their significant impact on the value of fed cattle.

Study Limitations

The Igenity beef panels continue to be redefined and improved with the discovery of new SNPs. In fact, new SNPs discovered since 2004 have been added to some of the panels. Moreover, the Igenity beef panels will continue to improve as technology advances.

Some important information pertaining to the data set was unknown. No information on management and production systems was given. Therefore it was uncertain how cattle were moved, penned, and fed. It was also uncertain how cattle were initially selected to be placed into the feedlot. For example, it was unknown if cattle were selected based on high quality, low price, or uniform lot size. Further, a data set from a large sample of genetically different cattle of *Bos taurus* and *Bos indicus* cattle was used. Cattle were not sourced from one location and were not uniform in structure, age, and gender. These inconsistencies may have added noise to the models.

Suggestions for Further Study

Further investigation into how Igenity panels affect economic value of fed cattle across a specific breed or location could be assessed. In this study, multiple breeds of cattle sourced from various locations were assessed. Data from a specific group of angus or angus cross *Bos taurus* influenced cattle should be tested. Further, controlling or holding constant days-on-feed and placement weight could provide more definitive results.

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APPENDICES

Appendix Table 1. Regression results for sire breeds

Sire Breeds	Base Price $1.45 per lb. (Std. Error)	DOF (Std. Error)	Wt_0 (Std. Error)
SIRE_1 (Angus)	2.68	-0.12***	0.41
	(37.16)	(0.07)	(0.38)
SIRE_2 (Angus Cross)	7.57	-0.08	0.46
	(38.77)	(0.07)	(0.40)
SIRE_3 (Red Angus)	12.30	-0.06	1.18*
	(39.56)	(0.07)	(0.41)
SIRE_4 (Red Angus Cross)	-32.40	0.01	0.39
	(48.64)	(0.09)	(0.51)
SIRE_6 (BABA)	-242.45*	0.04	0.06
	(80.17)	(0.15)	(0.86)
SIRE_7 (BNBN)	-155.55***	-0.02	3.16**
	(80.89)	(0.24)	(1.27)
SIRE_8 (Charolais)	-87.22**	0.11	1.19*
	(40.69)	(0.07)	(0.42)
SIRE_9 (Gelbvieh)	-34.78	-0.05	0.47
	(38.75)	(0.07)	(0.40)
SIRE_10 (Horned Hereford)	-24.72	-0.14***	0.73
	(42.25)	(0.08)	(0.44)
SIRE_11 (Polled Hereford)	-29.82	-0.10	0.37
	(39.57)	(0.07)	(0.41)
SIRE_12 (Simmental/Angus Cross)	15.52	-0.14***	0.20
	(39.70)	(0.07)	(0.41)
SIRE_13 (Simmental)	43.02	-0.07	0.98**
	(38.05)	(0.07)	(0.39)
SIRE_14 (Unknown)	9.08	-0.08	-0.01
	(41.21)	(0.08)	(0.44)
SIRE_16 (Maine Anjou)	-23.71	-0.12	0.80
	(55.44)	(0.11)	(0.61)

*Significant at $p \leq 0.01$.
**Significant at $p \leq 0.05$.
***Significant at $p \leq 0.10$.

Appendix Table 2. Regression results for dam breeds

Dam Breeds	Base Price $1.45 per lb. (Std. Error)	DOF (Std. Error)	Wt_0 (Std. Error)
DAM_1 (Angus)	17.10	-0.04	0.39***
	(17.94)	(0.04)	(0.21)
DAM_2 (Angus Cross)	12.29	-0.08**	-0.12
	(17.32)	(0.03)	(0.20)
DAM_3 (Angus/Hereford Cross)	32.22	0.02	-0.03
	(24.55)	(0.05)	(0.30)
DAM_4 (Angus/Gelbvieh Cross)	-10.60	0.08***	0.59**
	(22.91)	(0.04)	(0.26)
DAM_5 (Angus/Polled Hereford Cross)	-0.12	-0.06	0.27
	(22.26)	(0.04)	(0.26)
DAM_6 (Angus/ Santa Gertrudis Cross)	-5.02	0.08	0.05
	(32.04)	(0.06)	(0.36)
DAM_7 (Angus/Simmental Cross)	13.62	-0.04	0.25
	(19.69)	(0.04)	(0.23)
DAM_8 (Red Angus Cross)	71.55*	-0.13*	-1.84*
	(24.63)	(0.05)	(0.27)
DAM_9 (BABA)	264.38*	-0.10	0.48
	(76.38)	(0.14)	(0.83)
DAM_10 (BNBN)			
DAM_11 (Charolais/Angus Cross)	7.22	-0.04	0.15
	(28.03)	(0.06)	(0.32)
DAM_12 (Charolais)	89.34*	-0.08	0.62***
	(29.31)	(0.06)	(0.36)
DAM_13 (Charolais Cross)	-25.57	-0.05	0.90*
	(26.26)	(0.05)	(0.32)
DAM_14 (CXB)	106.32*	-0.19*	-0.78**
	(30.39)	(0.06)	(0.35)
DAM_15 (Gelbvieh Cross)	24.43	0.01	-0.47
	(37.36)	(0.07)	(0.42)
DAM_16 (Gelbvieh/Red Angus Cross)	4.96	-0.04	0.29
	(22.88)	(0.04)	(0.26)
DAM_17 (Gelbvieh)	13.73	0.00	0.02
	(26.35)	(0.05)	(0.30)
DAM_18 (Polled Hereford Cross)	-2.69	-0.05	0.27
	(19.54)	(0.04)	(0.23)
DAM_19 (Horned Hereford)	-36.72	0.00	-0.05
	(28.94)	(0.06)	(0.34)
DAM_20 (Simmental/Angus Cross)	13.07	-0.04	0.79**
	(28.23)	(0.06)	(0.34)
DAM_21 (Simmental Cross)	-4.80	-0.02	0.00

Appendix Table 2. Regression results for dam breeds

Dam Breeds	Base Price $1.45 per lb. (Std. Error)	DOF (Std. Error)	Wt_0 (Std. Error)
	(22.87)	(0.04)	(0.26)
DAM_22 (Tarentaise)	45.04	0.17*	-0.40
	(30.94)	(0.06)	(0.35)
DAM_23 (Unknown)	37.89***	-0.08**	0.76*
	(20.42)	(0.04)	(0.24)
DAM_24 (Other)			

*Significant at p ≤ 0.01.
**Significant at p ≤0.05.
***Significant at p ≤ 0.10.

VITA

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Master of Science

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Scope and Method of Study:

Cattle phenotypes are determined by management and genetics. Beef carcass marbling, tenderness, weight, and fat content are economic traits that are affected by these factors. Economically-relevant traits are typically influenced by numerous genetic markers. Hence, genetics determine, in part, the profitability of fed cattle. Genetic testing companies, such as Merial Igenity, have made it easier for cattle operators to make selection and management decisions through marker assisted selection. This study determined the economic value of genotypic information from the Merial Igenity panels for fed cattle.

A sample of 2201 head of fed steers and heifers were used to estimate a profit function with days-on-feed, placement weight, placement age, Igenity panels, sire and dam breeds, and source as independent variables. As days-on-feed and placement weight may be influenced by Igenity panel markers, separate equations were estimated with Igenity panels as independent variables. Using the estimated models of profit, days-on-feed, and placement weight, total marginal effects were found by totally differentiating the profit function and substituting in estimated coefficients from the regression models. Prices for fed cattle, quality and yield grade premiums and discounts, and hot carcass weight were varied over a range of values to assess the sensitivity of estimated effects of Igenity panels on profit.

Findings and Conclusions:

The Igenity panel scores for marbling and average daily gain had a significant and positive impact on fed cattle profits. With average grid prices, cattle operators could expect to gain $3.96 for each additional increase in Igenity marbling score and $6.26 for each additional increase in Igenity average daily gain score. Other Igenity panel information such as yield grade, ribeye area, tenderness, and residual feed intake should not be overlooked. Although, their marginal profitability was lower and varied in sign, they require more analysis to understand their impact on the value of fed cattle.

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