The Economics of Genetic Testing for Beef Cattle: Past, Present, & Future

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Abstract

Commercial genetic testing services targeted at the beef industry have become quite common in recent years, with many in the beef industry promoting the benefits they provide. However, economic considerations of financial feasibility are limited. What little work that has been done has focused on the use of genetic information to improve feedlot management decisions for commercial cattle. Generally, this work was unable to substantiate positive economic returns. Despite the lack of current economic rationale, the potential for this technology remains strong. In this article, we provide a brief overview of the work that has been done with respect to economics of genetic testing in the beef industry as well as a discussion of future opportunities and challenges. Mainly, this revolves around what is needed to achieve a scenario of cost-effective genetic testing – either increasing the value of genetic information or decreasing the cost of the test. While animal scientists are working to provide more accurate tests that have the potential to increase the value of genetic information, producers seeking to use this technology have no control over the rate at which these new variations are released. Therefore, at present, increasing the value of genetic information will require additional vertical coordination or cooperation among different sectors of the beef industry as well as more efficient price signaling. On the other hand, reducing the cost of the test could also help in achieving cost-effective implementation of genetic testing. Two specific scenarios are discussed: (i) offering reduced profiles of genetic information relevant to a specific decision at a reduced cost and (ii) randomly sampling a subset of a group of cattle for genetic testing to measure the genetic potential of the group.

Introduction

The availability and popularity of genetic testing services targeted at the beef industry has increased markedly in recent years. Commercial testing services offer tests for a range of information, including parentage assignment, detection of genetic defects, and genetic markers for a variety of qualitative (e.g., hide color and polled/horned) and quantitative (e.g., average daily gain and marbling score) traits. A recent review of commercially available genetic tests can be found in Ballenger et al. (2016). The information derived from these tests has the potential to generate value throughout the beef cattle supply chain (Van Eenennaam and Drake, 2012). However, the beef industry is made up of several disaggregated sectors: seed-stock, cow-calf, stocker/backgrounder, feedlot, and processer. As a result, the potential for and distribution of value within the industry will depend on the specific application (Van Eenennaam and Drake, 2012). The value of genetic information is generally classified into two sources: selection and management. Genomic selection is the process of selecting breeding stock that will produce offspring with desired genetic traits. Genomic information can also be used to improve management decisions. For instance, animals with varying genomic profiles may be fed different rations or for different numbers of days on feed, may be treated differently in terms of implant and beta agonist strategies, or targeted to different value-added marketing alternatives.

Regardless of the source of value, the ultimate test of financial feasibility is a comparison of the value of genetic information with the cost of the test. To date, economists have considered few of these tests and their value to producers. The goal of this article is to provide a brief overview of the research that has been done with respect to the economics of genetic testing in the beef industry, which largely is focused on using genetic information to improve feedlot management decisions for commercial cattle. In addition, the future opportunities and challenges of implementing genetic testing in the beef industry are discussed.

The Leptin Gene

Early interest in genetic testing for beef cattle mostly revolved around the leptin gene, which is associated with fat deposition (Buchanan et al., 2002). These tests rely on a few single nucleotide polymorphisms (SNPs), which are variations in nucleotides at specific points in the DNA sequence. Given their association with fat deposition, tests for leptin were particularly relevant to the feedlot sector where intramuscular (marbling) and external carcass (yield grade) fat have economic consequences, especially for cattle priced on a grid. During the mid to late 2000s, many commercial feedlots reported using these tests extensively managing feedlot cattle (Kolath, 2009), although many abandoned use within just a few years (Van Eenennaam and Drake, 2012). However, to imply that disadoption was directly due to minimal financial return may be misleading given that it is confounded with a period of increasing corn prices which resulted in large negative feedlot returns.

A series of articles in the late 2000s by DeVuyst et al. (2007), Lusk (2007), and Lambert (2008) were the first to address how the value of tests for leptin genotype compares to the cost of the test. Each of these three studies specifically focus on the value at the feedlot stage using similar methodological approaches. While results from the three studies differ with respect to the most profitable leptin genotype, they consistently report positive value associated with using genetic information to manage and select cattle for placement. Management in each of these studies is limited to varying optimal days on feed for each leptin genotype. This results in small but positive value – generally less than $2 per head – as it is found that leptin genotype had little effect on optimal days on feed. Compared with the cost of testing, which was around $40 per head at the time, these tests were not considered economically feasible for management. On the other hand, differences in expected profit between the best and worst performing genotypes were as much as $60 per head. Therefore, the ability to select feeder cattle with certain genotypes for placement, or bid differently based on genotype, could be advantageous. However, as a result of the segmented structure of the beef industry, asymmetric information between buyers and sellers exists. That is, the current feeder cattle marketing system is largely reliant on live cattle auctions in which cattle are priced solely on weight (Chymis et al., 2007). Other unobservable quality characteristics, such as genetics, and knowledge of upstream production practices are not costlessly transparent to buyers. Thus, these values are generally unattainable.[1]

Genomic Marker Panels

In recent years, tests for leptin are replaced with more precise genetic data, in the form of genomic marker panels, for a variety of economically relevant traits. These marker panels include several, potentially hundreds or even thousands, SNPs to better predict outcomes of interest. Moreover, the availability of marker panels for

1 Reputation effects have been previously documented in feeder cattle markets by Turner et al. (1993) and Schulz et al. (2015), and may represent an opportunity to attain premiums for higher quality cattle. However, these reputations can take years to build and are limited to buyers that have bought your calves in the past.

several traits allows decision makers to better consider the chance that selecting for desirable attributes would have adverse effects on other economically relevant traits. As a result of these advancements, a series of papers reevaluating the economic feasibility of genetic testing for feedlot cattle was recently conducted by Thompson et al. (2014, 2016). Using a sample of 10,209 commercially fed cattle, these studies attempt to estimate the expected value of genomic information for seven economically relevant traits: yield grade, marbling, average daily gain, hot-carcass weight, rib-eye area, tenderness, and days on feed. An economic simulation similar to previous studies is used to generate estimates of the value of genomic information.

Two different scenarios of using genomic information to improve feedlot management are evaluated. First, management is defined as sorting cattle by optimal days on feed similar to previous studies. This analysis yields results similar to previous studies with values of around $1 per head for each of the traits evaluated, well below the cost of testing (around $40 per head).[2] However, as was previously mentioned, there remains potential to increase the value of genomic information by using it to improve other management decisions within the feedlot, including how cattle are fed and marketed. Therefore, the second scenario estimates, for the first time, the value of using genomic information to improve fed cattle marketing decisions, including decisions for both marketing method (live weight, dressed weight, or grid pricing[3]) and timing to market (days on feed). Results indicate that the value of using genomic information to sort and selectively market cattle ranges from $1-$13 per head depending on how a producer currently markets cattle and the structure of the grid. Although these values were generally higher than those reported in previous research, they were still not enough to offset the current cost of testing. Nonetheless, sorting cattle into marketing groups also led to efficiency gains, including more accurate optimal days on feed and reduced variability of returns to cattle feeding. For example, animals with higher genomic potential for carcass quality characteristics (yield grade and marbling) could be fed longer and targeted towards the grid. On the other hand, lower quality animals who would never reach more favorable quality outcomes could be fed for fewer days and targeted toward live weight or dressed weight pricing to avoid the excess feed costs and large discounts they would receive on the grid. Therefore, the use of genomic testing to selectively market cattle may encourage producers, who might not otherwise do so, to market cattle on a grid. This marketing technique will result in improved quality and consistency of beef products and improved transmission of market signals throughout the beef cattle supply chain (Fausti et al., 2013).

In addition to scenarios of management above, results indicate that using genomic information to select cattle for placement in the feedlot is as much as $38 per head. Again, genomic information is rarely available to the purchasers of feeder cattle prior to bidding given the disaggregated structure of the industry. Hence, this value is not practically attainable. Nonetheless, this value provides an estimate of the premiums and discounts that feedlots could place on cattle with varying levels of genomic potential. Moreover, knowledge of the traits which generate the most value to the feedlot sector may also guide selection decisions in the breeding sector. For instance, Thompson et al. (2014) identified average daily gain and marbling as the most economically important traits for feedlot cattle priced on a grid. However, it is important to note that selecting breeding stock for traits that are valuable in the feedlot sector may or may not be advantageous in other sectors. Future research must consider the impacts of these traits on other sectors.

Despite recent improvements in the accuracy of genomic marker panels, the implications of these results are qualitatively similar to previous studies evaluating the economic feasibility of tests for leptin genotype. That is, using genomic information to improve the management of feedlot cattle remains unprofitable, even when management decisions beyond days on feed are included in the scenario. In addition, the value of using genomic information to select feeder cattle for placement in the feedlot is much higher. Although, these values are still practically unattainable given that genomic information is generally unavailable to feedlots prior to purchasing feeder cattle.

2 The absolute cost of testing to the producer is roughly the same as it was a decade ago (around $40 per head), but current genomic testing services provide considerably more information than tests for leptin genotype. That is to say that the cost of the technology has decreased. However, the current "bundling" of genomic testing products/services results in little change in what producers pay for this suite of information.

3 For more information on fed cattle pricing mechanisms see Hogan et al. (2009).

Future Opportunities and Challenges for Genetic Testing in the Beef Industry

Based on the discussion above, one might conclude the economic outlook for genetic testing in the beef industry is bleak. Nevertheless, opportunities for this technology remain, and in fact, many within the industry firmly believe this technology will revolutionize beef production. While the potential is clear, there are many challenges on the road to realizing the full potential of genetic information in the beef industry.

For one, it is important to reiterate that the studies discussed above exclusively evaluate the value of genetic information for improving management decisions for commercial cattle at the feedlot stage. However, as mentioned earlier, the beef cattle supply chain is made up of several disaggregated sectors, each having unique potential for applying genetic testing. Van Eenennaam and Drake (2012) provide a general discussion of how genetic information may generate value within each sector of the beef industry. They conclude that the value created is largely dependent on the number of descendants an animal produces. Hence, the potential to increase the accuracy of selecting breeding stock and accelerate the rate of genetic gain is highest among breeding sectors – specifically the seed-stock sector where stud animals can sire hundreds or even thousands of offspring. This is consistent with the values of marker-assisted selection discussed above and is supported by current trends in the use of commercial genetic testing, which is predominantly observed among seed-stock producers and breed associations. Yet, research by Vestal et al. (2013) showed that the inclusion of genetic information in a bull sale catalog did not result in higher bull prices. Although they partially attributed this to a lack of understanding of genetic information, the inability to recoup testing costs even within the industry's highest potential sector is a challenge to the progress of genetic testing.

Despite the potential for genetic testing to generate value throughout the beef industry, at present the cost of testing generally exceeds the value returned to any single sector (Van Eenennaam and Drake, 2012). Therefore, in order to achieve a scenario of cost-effective genetic testing, either the value of genomic information must increase or the cost of testing must decrease. While animal scientists are working to provide more accurate tests that have the potential to increase the value of genetic information (Thallman et al., 2010), producers seeking to use this technology have no control over the rate at which these new variations are released. In addition to the accuracy of genomic tests, the value of genetic information is also limited by the segmented nature of the beef cattle supply chain. Explicitly, misaligned incentives between producers at different points in the supply chain inhibit information flow. For example, the revenue of cow-calf producers is a function of calf weight rather than feed efficiency or rate of gain potential of their calves, traits that are important for stocker and feedlot operators. Similarly, desirable traits for feedlots and processors do not always align with consumer preferences, and thus willingness to coordinate and share in the costs and benefits of genetic testing is limited. This lack of vertical coordination in the beef industry relative to pork and poultry is well documented (Ward, 1997). In fact, in the mid-1990s grid pricing was introduced in an attempt to provide transparent price signals and align incentives throughout the supply chain. However, other than situations of retained ownership, these signals only reach upstream as far as the feedlot, which has no control over breeding decisions limiting effectiveness. Therefore, additional vertical coordination or cooperation as well as more efficient price signaling are likely needed to create opportunities for profitable genetic testing.

In addition to increasing the value of genetic information, another way to achieve cost-effective genetic testing is to reduce the cost of the test. As technology has progressed the per-unit cost of genetic information has declined. However, current marketing of commercial testing services generally relies on bundling a number of traits that may or may not be of interest or of value to producers. One alternative may be to provide individual or subsets of traits that are relevant to a particular decision or sector at a reduced cost. For example, the sorting and management of feedlot cattle into marketing groups (live weight, dressed weight, or grid pricing) in Thompson et al. (2016) relied solely on genetic information for yield grade and marbling and generated value of up to $13/head. However, at present to obtain this information would require purchasing a product that contains a number of other traits at a cost of $40/head. Some companies have started offering reduced profiles of genetic traits relevant to the selection of replacement heifers at a reduced cost. Similar products target other decisions or sectors, such as a reduced profile of growth and carcass characteristics for management of feedlot cattle, may enhance opportunities for profitable applications of genetic testing.

Another strategy for reducing the overall cost of testing is random sampling. That is, the underlying assumption of the discussion up to this point has been that each individual animal would need to be tested in order to sort and manage cattle based on genetic information. However, what if instead of testing each individual animal in a group, a random sample of animals from a given ranch or pen could be tested to measure the genetic potential of the group? This would allow us to reduce the overall cost of testing for the group, while still being able to make management decisions that take into consideration the genetic potential. Each additional animal sampled provides information about the quality distribution of the group but also increases the cost of testing. So, how many animals should you sample to maximize returns?

A recent study by Thompson et al. (2017) attempted to shed light on this question by using a Bayesian approach to determining the economically optimal sample size. Results indicate that the marginal benefit to testing is high for small sample sizes suggesting that a large portion of the additional value for higher quality cattle can be captured by testing a relatively small portion of the group. For example, at the baseline parameter values, the optimal sample size was nine animals from a group of 100, and the returns from sampling were nearly $8 per head, resulting in a 222% return on investment. Sensitivity analysis revealed that these results varied depending on the difference between buyer and seller expectation of quality prior to testing, the expectations variability of quality between and within pens, and the cost of the test. Nonetheless, over a wide range of scenarios random sampling is found to provide a context in which the benefits of genetic testing can outweigh the costs, making this the first research to demonstrate cost-effective genetic testing for the beef industry.

Conclusions

In this article, a brief review of research that has been done related to genetic testing in the beef industry is provided. While the information derived from these tests has been shown to create value, at present the cost of the test is too high for testing to be profitable in any one sector. However, the potential for these tests to improve the profitability and efficiency of beef production remains. A number of these opportunities and challenges are discussed, including recent work evaluating random sampling as a strategy to reduce the overall cost of testing. Although this appears to provide the first context for cost-effect genetic testing in the beef industry, there is still much work to be done estimating the value of genetic information and creating opportunities for profitable applications. Future research should look to provide estimates of the value of genetic information throughout the beef cattle supply chain, and look for opportunities to increase vertical coordination or cooperation as well as improve price signaling. Better aligning incentives throughout the beef cattle supply chain will allow producers to better share in the costs and benefits of genetic information. By reducing asymmetric information, breeding sectors with genetics that are valued by downstream sectors (feedlots and processors) will have the opportunity to be compensated for those genetics. Compensation provides the incentive to produce more consistent and higher quality beef products that conform to consumer preferences. In doing so, the potential exists to improve efficiency and increase profits throughout the beef industry.

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