The Economics of Genomic Information Sharing in the Alberta Beef Sector

by

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Abstract

In this thesis, I estimate the willingness-to-accept (WTA) for genomic information sharing in Alberta beef cattle production. In addition, I examine the factors that influence the WTA by commercial cow-calf producers in genomic information sharing with Breeding Associations (BAs). As part of this thesis, I conducted a survey among the commercial cow-calf producers in Alberta. In total, 52 respondents completed the survey. Through the survey, I find that educational background, farm size, farm operation and the type of information all affect the willingness to share information. Larger farms and those that already have systems in place to collect genomic data easily are more willing to share their information at a lower price. Furthermore, respondents with genomic-related majors are more willing to share their information. Lastly, the perception about the benefits of genomic information sharing also influences respondent behavior. My results show that paying producers can be an effective tool to encourage cow-calf producers to share genomic information with BAs. However, the type of information and the degree of difficulty associated with collecting the information matter a great deal.

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Chapter 1. Introduction

1.1. Introduction

1.1.1. Background

The Canadian beef cattle industry plays an increasingly significant role in the agricultural sector, and makes an important contribution to the overall national economy. Annual farm cash receipts due to calves and cattle in Canada accounted for $9.1 billion in 2020. During the period of 2018 and 2020, beef production contributed to the national GDP around $21.8 billion averagely (Canada Beef 2021). Canada is also one of the largest beef and livestock exporters: approximately 45% of Canadian beef and cattle production is exported each year (CCA 2019). In 2018, Canada exported $2.75 billion worth of beef, which accounted for 38% of total domestic slaughter. Japan, Mexico, Hong Kong and Macau are also the major destination for the exporting. Alberta is by far the most important province when it comes to the beef sector. The 2016 Census of Agriculture counted more than 40,000 beef cattle farms in Alberta, accounting for 41.6% of the national herd. In addition, Alberta has 70% of the feedlot and processing capacity in Canada due to its ideal environment for raising beef cattle (ABP 2019).

The Alberta beef cattle production system, which is similar to that of the other Canadian provinces and the U.S., is comprised of three different activity levels: cow-calf operations, backgrounding operations, and feedlot/finishing operations (Athwal 2002). Cow-calf farms can be both purebred and commercial operations (Bruce 2017). Purebred operations, or breeders, as the principal seedstock suppliers, are an important level in the beef supply chain (The Beef Site 2009). Genetic improvement is a key focus for a breeder. The principal products of purebred breeders are purebred or registered bulls, cows, heifers, semen, and embryos as value-added beef cattle genetics. For commercial beef cattle producers, bulls, as their production input, have an important impact on their economic returns (Dhuyvetter et al. 1996). Bulls represent approximately half of the genetic makeup of any year's calf crop and 90% of cowherd change for the producers who keep their own heifers (Wagner et al. 1985; Dhuyyetter et al. 1996). In general, animals raised by purebred breeders are registered under breeding associations (BAs), and commercial cattle are usually not registered animals and may be crossbred. In order to register under a BA, breeders must pay a registration fee. In addition, different BAs require various animal trait data for future genomic estimations, usually including but not limited to the following: birth and weaning date, performance information such as birth weight, weaning weight and yearling weight, and ultrasound body composition scan results that show the ribeye area, backfat thickness and intramuscular fat percentage. In return, breeders can obtain marketing services and expected progeny differences (EPDs)[1] that provide estimates of the genetic worth of an animal as a parent (The Beef Site 2009). Marketing seedstock cattle is distinct from marketing commercial cattle. First, there are differences in product and product value. The base value of a breeding animal is determined by its salvage value, and its value above slaughter value depends on its producing ability. In the breeding animals' market, perceptions of "quality" vary among producers since producers have different trait of interest. Therefore, it is important to have the animal trait estimations as added value when breeders market and sell their bulls to ranchers (The Beef Site 2009).

[1] **Expected Progeny Differences (EPDs)** provide estimates of the genetic worth of an animal as a parent. EPDs are based on animal models which aggregate all information known about an individual and its relatives to build a genetic profile of its merits. These profiles are then compared to other individuals used for the breeding decision making of producers. However, these estimates are only compared to the individuals of the same breed.

1.1.2. Genomic Selection and Genomic Information Sharing

Genomic selection (GS) is a technique aimed at identifying and locating specific markers scattered across the genome of an animal so that these markers can be used in selection decisions. Breeders use both observed traits and genetic information to specifically develop and propagate traits of interest in the offspring. While conducting agricultural activities, such as raising animals and cultivating crops, improvements in breeding and selection for economically important quantitative traits traditionally relied on an animal's or plant's performance information (i.e., phenotypic data of the individual and its relatives) or estimated breeding values (EBVs)[2] (Meuwissen et al. 2001; Dekkers 2012; Boaitey 2017). This selection process is considered as traditional selection in this study. Another selection approach, marker assisted selection (MAS)[3], uses marker information in breeding and selection. This is a molecular technique. These markers identify variations in DNA sequences related to specific traits. Distinct from these techniques, GS uses whole genome molecular data in estimating the genetic merit of an individual (Goddard and Hayes 2007). GS and MAS are both marker-trait associations and used for breeding purposes (Arruda et al, 2016). They are similar but have certain differences, such as the differences in applications and the way of markers being used for estimating breeding values.

GS is an advanced technique that estimates the genetic performance of an animal by incorporating information from thousands of markers on the genome of this individual. In recent decades, GS has proven to be a powerful technique for estimating the genetic values of livestock

[2] **Estimated Breeding Values (EBVs)** expresses the difference of each animal traits in the performance of an individual relative to the breed or herd benchmark.
[3] **Marker assisted selection (MAS)** uses molecular markers, such as single nucleotide polymorphism (SNP), to assist phenotypic selection in crop and animal breeding improvement.

and crops in the agricultural sector (Zhang et al. 2019). The process of GS involves the establishment of a linkage between a DNA sequence and the relevant traits in a reference or training population that requires both genotypic and phenotypic information. Then, the genomic breeding values of animals outside the training population are predicted based on their genotypic information (Hayes 2007). Compared to traditional selection, which may take years, GS has brought considerable benefits to producers by significantly reducing the time required for selection, by developing the superior genotypes, by improving the productivity of the cowherd, and by improving the efficiency of selection (Hayes et al. 2013). The study by Lusk (2007) estimated the economic value of using information on leptin genotype to select and manage beef cattle. The results of his study showed that the value of genomic information is in allowing cattle producers to select animals with specific genotypes that lead to superior economic performance.

1.1.3. Motivation for the Research

While purebred producers are required to share their animal trait information with BAs, this kind of information sharing happens solely between purebred breeders and BAs. Data from the animals whose parents are sold to commercial producers as breeding cattle is not reported to BAs. The more data that are collected, the more accurate estimations can be obtained (Meuwissen et al. 2016). In general, from the BAs' perspective, collecting commercial data and enlarging phenotypic dataset for genomic estimation is valuable. In addition, at the farm level, ranchers can have more stable outputs and higher profits by obtaining accurate EPDs. However, the adoption of GS in the beef industry has been slow compared to that in the dairy industry, which causes the slow improvement in the accuracies of genetic estimations for the beef cattle sector (Hayes et al. 2013). One potential reason is that the effective population size of beef cattle is generally smaller than those for dairy cattle. That makes beef cattle has fewer sires with highly accurate progeny tests than in dairy cattle. Another possible reason is the breed heterogeneity (Hayes et al. 2013). For beef cattle, there are many different BAs aiming to develop and improve distinct breeds whereas the global dairy cattle population is dominated by only a couple of breeds. In addition, it is uncommon for breeding associations to exchange genetic information and estimated EPDs. This further hinders the objective of establishing large reference populations to achieve highly accurate genomic breeding values for individual beef breeds (Hayes et al. 2013).

In recent decades, especially at the farm level, the cattle raising industry has become increasingly competitive due to the challenges stemming from higher farm input costs, fluctuating beef prices, consumer perceptions on animal health and food safety, export market access, and climate change (López-Campos et al. 2013; Lawrence et al. 1999; Schroeder et al. 1993). At the wholesale level, the Canadian beef-processing industry is very concentrated and highly depend on the trade relationship with the U.S. beef cattle market (Miljkovic 2009). Compared to other livestock industries, beef cattle ranching and farming is less profitable. In 2017, the average operating profit margin for beef cattle operations in Canada is 8.9 cents, which is much lower than the profit margin for dairy cattle and milk operations (21.3 cents), hog and pig farms (12.1 cents), and poultry and egg operations (17.8 cents) (Statistics Canada 2017). These low margins greatly limit the growth of the beef industry in Canada. To address these challenges so that beef suppliers can meet the expected increase in domestic and global demand, the beef cattle industry has developed numerous management strategies and advanced production technologies to improve efficiency, to reduce input cost, and to create a more profitable and competitive beef cattle industry (López-Campos et al. 2013). In addition, due to a rapidly growing global population, food supply systems in many countries are facing increasing demand;

therefore, the output must be increased, and production efficiency has to be improved. For beef producers, who are supplying one of the main protein resources, this challenge is even more severe. The adoption and use of new genetic technology (e.g., genomics) can be significant in meeting the challenges of increased production with minimal environmental impact. However, the benefits of this kind of production-based innovations are only achieved when producers are willing to adopt. For the different production levels (i.e., cow-calf operations, backgrounding operations, and feedlot/finishing operations), the benefits are shared according to the additional cost of adopting the new technology in each phase (Boaitey 2017).

As discussed in the above part, limitations in information sharing of the beef cattle operation might be related with many different elements. Due to the limitations, the effectiveness of the genomic selection in the beef cattle industry is low. It can then be one of the reasons for the lower average operating profit margin in this industry comparing to other agricultural sectors. It is a fact that information sharing between BAs and cow-calf producers can be helpful for improving the accuracy and efficiency in GS. Feedback from cow-calf producers can help BAs to collect data about how the cattle perform in different type of environment. Moreover, this kind of data might also be helpful for breeding associations to know better about different variables which can influence on the performance of cattle. Phenotypic information sharing between purebred breeders and BAs is easy. However, there is an information asymmetry exiting between BAs and commercial producers. It might not be possible for BAs to capture the information of unregistered animals. Nevertheless, it can cost a lot of time and money for commercial producers to gather animal trait data. The process of implementing phenotypic information sharing might have certain difficulties, such as security of the information, the argument about duty and responsibility of two parties in the information sharing and the protection of commercial secret.

Therefore, how to implement information sharing effectively between BAs and commercial cow-calf producers can be important issue to consider. In this circumstance, commercial data sharing requires an incentive for commercial producers. With this thought, this research would be made.

1.2. Research Objectives

The purpose of this study is to investigate the feasibility of setting up incentive schemes to help collect genomic information from commercial cow-calf producers. Specifically, I investigate how animal phenotypic data collected by commercial cow-calf beef cattle producers can be shared with BAs that play an important role in EPDs estimation. Commercial information is immensely valuable for genomic selection purposes in the beef sector and collecting it could offer a real improvement to genomic selection in Canada. The research will focus on the willingness-to-accept (WTA) by commercial producers to share these animal-trait related information.

In this thesis, the objectives are:

1) To evaluate the current level of genetic information sharing between the stakeholders along the beef production value chain;

2) To identify the factors that influence the WTA for commercial cow-calf producers to share their information; and

3) To provide guidance on how to increase the amount of information sharing between commercial cow-calf producer and BAs.

1.3. Thesis Structure

The thesis consists of six chapters. The first chapter focuses on the background that motivates the research, highlights the importance of this study, and introduces the objective of the study. Chapter 2 conducts a literature review of the current landscape for genomic information sharing in the beef sector, and identifies gaps that this study aims to address. Chapter 3 covers the data collection process and describes the summary statistics. Chapter 4 introduces the methodologies used in the study. Chapter 5 presents the results from the analysis of the WTA results. Chapter 6 concludes the thesis, discusses the implications of the research, identifies limitations of the study, and provides suggestions for future research.

Chapter 2. Literature Review

2.1. Introduction

This chapter reviews and summarizes the related studies to this thesis. Information sharing and information transmission in beef industry are reviewed to present the background of this research. Then, the importance of genomic information is presented. In addition, agricultural technology adoption and farm level decision making are reviewed to illustrate the importance of this study and potential factors that can influence the producers' willingness-to-accept (WTA) of information sharing.

2.2. Literature Review on Information Sharing

As modern technology and media become more advanced and ubiquitous, information transmission among players in the same industry is easier, more common, and more convenient. Studies on information sharing within the industry have been conducted both vertically (i.e., information sharing along the supply chain) (Lee and Whang 2000; Fiala 2004) and horizontally (i.e., information sharing among similar producers) (Lozano 2012; Lemarié and Marcoul 2018).

Information sharing in a supply chain is a popular topic in recent decades (Lee and Whang 2000; Yu et al. 2001; Fiala 2004). In order to minimize risks of decision making on significant investments, it is important to allow information to be shared across entities so that activities and decisions along the supply chain can be coordinated (Lee and Whang 2000). There are several studies about information sharing in beef industry. In the study made by Greenwood, Gardner and Ferguson (2018), beef production in Australia has a high efficiency which makes this country to be one of the world's most efficient producers of cattle and the third largest beef exporter in the world in 2016. The high-quality performance and high efficiency of Australia beef production are related with the pasture-based cow-calf systems, a backgrounding or grow-out period on pasture and feedlot finishing. Selection process is also considered importantly in this system. The study made by Wilson (2021) stated the importance of breeding. With the suitable genomic selection, beef producers can gain more competitive power. However, in practice, BAs and commercial cow-calf producers might not finish this process effectively by themselves. Moreover, information sharing is an important tool for cow-calf producers to seek for risk information for reducing the potential threats in their operation process (Waggie, 2020). Because of this, the information sharing between commercial cow-calf producers and BAs can help BAs for having more effective and more accurate genomic selection. It can also be beneficial for the cow-calf producers. According to Dube-Takaza, Shoko, Mudziwapasi and Jomane (2021), genomic selection is an important way for improving animal health. In addition, in the study made by Estévez-Moreno et al (2021), information about cattle temperament should also be involved in the genomic selection of breeding process. Because of this, when cow-calf producers share their feeding information of their cattle, they can help BAs to have a better performance in genomic selection. This can benefit them back by raising higher performance animals with better price.

Lee and Whang (2000) defined different types of shared information in the supply chain, including inventory level, sales data, order status for tracking/tracing, sales forecast, production/delivery schedule, and other information sharing. What kind of information should be shared between cow-calf producers and BAs needs to be arranged between these two parties. Each type of information sharing that occurs in any stage in the supply chain allows the industry to be more competitive. Several challenges that can occur during information sharing in a supply chain are introduced in this article. The foremost challenge is to align incentives of different partners since information sharing and cooperation do not automatically increase the profit of all the players in the supply chain. Based on the discussion about the genomic selection and cattle performance information, it can find that the benefit for the information sharing can lead to certain win-win situation. BAs can have a better understanding about the performance of cattle for further genomic selection. While cow-calf producers can get the cattle from BAs with better performance. They can reduce risks in feeding process and have a better production amount and profit. According to the study made by Doublet et al (2019), genomic selection is good for increasing the production of cattle. Moreover, genomic selection can be helpful for genomic diversity and other benefits in cattle production. Improving the performance of the cattle can be the ultimate purpose of the information sharing. However, in the process, there are some risks in information sharing. Each player in the information sharing process is wary of the possibility of other partners abusing information or reaping all the benefits from information sharing. Even if all players can be guaranteed a positive gain in return for information sharing, each of them can play a non-cooperative game and haggle over "how much". Therefore, trust and cooperation are critical components in the supply chain partnership; however, this needs to be rationalized by a relevant economic return. Moreover, economic incentive plays an important role in information sharing.

Our study focuses on information sharing in the upstream of the cattle beef supply chain. According to interviews within the industry (Devani 2018; Stewart-Smith 2018; Verbeek 2018; Manafiazar 2018; Miller 2018; Irvine 2019), it is very important for breeding associations to obtain commercial data on animal performance for more accurate genomic estimations. However, commercial information is not commonly shared because there is a lack of economic incentives of commercial producers. In addition, beef supply chain has unique elements that are different from other livestock industries. According to Athwal (2002), cowherd is maintained and calves are raised in cow-calf operations. Calves are ultimately sold after they are weaned from their mother cows. Weaned calves (usually 6 to 8 months old), steers and heifers are the main outputs of cow-calf operations. Depending on breeds, production systems and market conditions, some weaned animals will enter a pre-finishing phase before they are shipped to a feedlot for finishing until slaughter. This is called backgrounding. During backgrounding, which is usually in the fall, producers over-winter the calves on silage or forage-based ration, and pasture them for weight gain (about 350 to 450 kg) in the spring. The end product of the backgrounding stage is feeder cattle (steers and heifers) which are shipped to feedlot operations. The feedlot/finishing operation is the final phase of raising beef cattle. Typically, feedlot/finishing operations buy feeder animals from backgrounding operations or directly from cow/calf ranchers and these animals are put on a high-energy ration to finish them to an appropriate slaughter weight. At this stage, feeder animals (calves) are fed with a grain-based diet to gain the needed fat (about 550 to 600 kg) at approximately 18 to 24 months of age. The animals are then referred to as fed cattle. Cows, bulls and fed cattle that are no longer useful for breeding will be processed into beef in the slaughterhouses. There are different levels of farms along the beef supply chain. Thus, information transmission highly depends on the integration level. There exists some evidence of vertical integration between different production levels within the beef supply chain. While the backgrounding process is commonly carried out by cow-calf producers, some beef processors also own feedlot operations (Athwal 2002). However, there is little evidence demonstrating partnerships between BAs and commercial cow-calf producers. More issues can involve how to guarantee the effectiveness of the information sharing and the security of data in the sharing.

The information sharing system can be supported by market performance data. Vasilev and Stoyanova (2019) stated that in the supply chain, information sharing can be implemented by the information technology (IT) system. Data of real-time market information can be uploaded to the IT system and can be analyzed directly for managing the supply chain system. Srivathsan and Kamath (2018)'s study about consumer demand have emphasized the importance and the value of information sharing in the supply chain network. With information sharing from the downstream in the supply chain, suppliers can know what kind of products or services are more popular in certain area and what should be improved for meeting the demand of consumers. In this way, the downstream participants and upstream suppliers can have more knowledge about market trend. In information sharing process between BAs and cow-calf producers, the basic benefits of this activity are similar. However, the ultimate aim of the information sharing might not be the same with the aim in other industries. In other industries, such as fashion industry and food industry, the taste or the demand of consumers might be changed. Therefore, information sharing can be consumer-centric and information involved is dynamic. In the case of the information sharing process between BAs and cow-calf producers, the one of the aims of information sharing is about the performance of genomic selection results. Information from cow-calf producers can help BAs to know how the offspring performance and what kind of potential risks might be involved. And commercial producers will be benefited by being able to get higher and more stable-performed animals.

In some specific industries, information related to product characteristics has significant influence on profit. Lemarié and Marcoul (2018) developed a dynamic oligopolistic Cournot model between pesticide firms where resistance to pesticides can develop. Based on the two different cases of demand for pesticide ("users coordinate" and "do not coordinate"), they found that users benefit from coordination, but the demand is also lower with coordination. In addition, they suggested that firms have incentives to acquire scientific information on the likelihood of pest resistance and to share this information among players, or even among their competitors. This kind of phenomenon also occurs in other industries such as antibiotics (Herrmann and Laxminarayan 2010), BT crops and other agricultural biotechnologies (Laxminarayan and Simpson 2002; Bourguet et al. 2005; Ambec and Desquilbet 2012). This type of information sharing usually occurs horizontally. Research in this field mainly focus on understanding firms' optimal decisions and the corresponding market equilibria. This branch of game theory refers to Bayesian Games, which is used when players do not have complete information about other players.

Moreover, in other studies about information sharing process, there are some problems have been stated. For example, the low trust degree between participants and untimely information exchange are both issues in information sharing process (Cui and Idota 2018). Low trust degree might influence on the reliability of data shared in the system. For the fast fashion or other industries which face on the dynamic market environment, speed of exchanging the information and trust level of the information can decide the production process of the suppliers. Nevertheless, in the beef sector, the speed of exchanging the information might not be required to be high. The level of trust is required for guaranteeing the genomic selection in the future. In other words, information sharing between BAs and cow-calf producers aims for more effective genomic selection and improvement of beef cattle industry. For making the process to be effective, participants in this process need to achieve the agreement with some issues. These issues are:

A. Type of information which refers to the details of data needed for genomic selection

B. Period for information sharing

C. Responsibility and duty of different participants in the process, such as sharing the information and guaranteeing the security of data.

In general, sharing information is an effective way for improving the performance of cattle. The benefit from this process would be achieved based on genomic selection. Thus, in the following part, the economic value of using genomic information in beef sector would be discussed.

2.3. Economic Value of Using Genomic Information in the Beef Sector

Many studies investigate potential factors that can affect the profitability of cattle farms in North America (Schroeder et al. 1993; Lawrence et al. 1999; McDonald and Schroeder 2003; Mark, Schroeder and Jones 2000; Trapp and Cleveland 1989). Some of these studies examine the effect of economic variables (i.e., feeder calf cost, feed cost, fed cattle prices, etc.) on profit (Lawrence et al. 1999; McDonald and Schroeder 2003; Trapp and Cleveland 1989; Mark, Schroeder and Jones 2000), whereas other studies investigate the effect of production variables [i.e., feed efficiency, average daily gain, hormonal growth promotants, ractopamine treatment, marbling score, lean yield percentage, hot carcass weight, etc.] on profit (Retallick et al. 2013; Lusk 2007; Thompson et al. 2016). With the development of genomic selection, all of these production variables can be estimated before an individual is birthed and grown. Van Eenennaam et al. (2014) defined genomic selection as the use of statistical methods, such as prediction equations, to estimate the genetic merit of a genotyped individual based on genotypes and phenotypes of its ancestors. By utilizing genomic selection, breeding associations can estimate more accurate EPDs, which are used by cow-calf producers in purchasing bulls. In addition, it is important for commercial producers to breed with bulls who have more accurate estimations of its offspring. This is because if the performance of the calves is predictable, they are more likely to have stable profits. The economic value of genomic information appears when producers use the information in both herd management (Lusk 2007) and breeding decision making (Retallick et al. 2013).

Lusk (2007) examined the economic value of utilizing information on leptin genotype to select and manage beef cattle. He conducted conditional analysis across different genotypes, where per head profit and revenue is regressed on production variables (i.e., placement weight, frame score at placement, days on feed, percent steer, genotypic dummy variables, etc.). The results showed that the value of using leptin information to select the number of days on feed is not very high. However, the value of using leptin information to optimize the selection of cattle is relatively high. In addition, his results also revealed that the value of genetic information lies in allowing cattle producers to select animals of specific genotypes with superior economic performance. In this article, the author also conducted static analysis. The results of the static analysis revealed that there exists statistically and economically significant differences across genotypes. The best performing genotype generated $23/head per year more profit than the type that generated the lowest profit level.

Retallick et al. (2013) examined the economic value of feed efficiency and identified performance, carcass traits, and feed efficiency characteristics that predict carcass value, profit, cost of gain, and feed costs. In this study, they estimated OLS regression of carcass value, profit, feed costs and cost of gain as a function of animal performance (i.e., average daily gain, dry matter intake, etc.), feed efficiency (i.e., feed conversion ratio, residual feed intake, residual intake, etc.) and carcass characteristics (i.e., hot carcass weight, marbling score, yield grade, etc.). The results showed that average daily gain, marbling score, yield grade, dry matter intake, hot carcass weight, and year born accounted for 81% of the variation in profit. Hot carcass weight, marbling score, and yield grade accounted for 96% of the variation in carcass value prediction. Average daily gain, dry matter intake, hot carcass weight and birth year accounted for 85% of the variation in the cost of gain. Thus, it is obvious that animal performance has significant influence on cattle farm profits. Furthermore, genomic selection, the technique that can affect animal performance, has important economic value in the decision making at the farm level.

Tompson (2018) hesitated that genetic information can be used for improving feedlot management for commercial cattle. However, Tompson figured out that the genetic information might not have the quick economic return to the commercial cow-calf producers because of the investment for the technology and other elements. Therefore, other participants in the beef industry should be involved in the process of information sharing and information analysis to increase the value of genetic information in commercial practice. Moreover, involving other participants in genetic information analysis can help cow-calf producers for saving cost in genetic testing. In other words, information sharing between BAs and commercial cow-calf producers can be considered as the process for integrating resources of different participants in the industry for maximizing the efficiency and reducing the costs for all the participants. Another benefit and economic value found in genomic selection for beef industry can be related with the quality of beef in the production. Raza et al. (2020) figured out that genome-wide association studies can be used for selection in breeding programs. With this kind of programs, meat quality and the efficiency in feedlot can be improved. Amaya, Garrick, Martínez and Cerón-Muñoz (2020) have listed some points in the economic value created by genomic selection in beef industry. These points include the increasing of cattle weight in a certain period, increasing of milk production and the age of first calving. These elements can help cow-calf producers to gain more economic profit. Moreover, the animal health can be improved and other potential risks of getting sick can be reduced. In this way, the cost of feedlot can be decreased. Thus, the economic profit can be increased. For BAs, data collected from commercial producers can enrich the database for genomic selection. Also, large scale data about cattle performance is necessary for them to make further selection decisions. To get large scale data about the growth and performance of cattle can cost a lot of time and money. Thus, data from producers can shorten the period of getting the information and the investment for making the experiment. Sharing information can also maximizing the economic value of genomic selection effectively.

DeVuyst et al. (2007) used data from 590 steers and heifers to simulate carcass traits of various days-on-feed and calculated the relevant profit based on three price grids. The economic models that estimated final marbling score, ribeye area, backfat, and weight of the calves are all regressed twice, with and without leptin genotypic information by using the three-stage least squares method. The results showed that leptin genotype impacts the value of finished steer or heifer by as much as $48 per head per year. However, leptin genotype has little effect on days-on-feed but genotyping of feeder cattle appears to break even at best. The genotype of an individual is always relevant to its phenotype. For example, a polymorphism in the leptin gene is associated with fat deposition. The market price of fed cattle based on a grid that take yield and quality grades into account Therefore, fat deposition has an important impact on profitability and the value of genomic information is reflected by an increase in farm level profit.

The study by Thompson et al. (2016) evaluated the value of genetic information for improving fed cattle marketing. The value of genetic information is apparent when producers sort cattle into market groups to improve efficiency. This leads to more accurate days-on-feed and greater stability of economic returns on cattle feeding. In this study, they estimated regression equations for average daily gain, dressing percentage, yield grade, and quality grade as a function of live-animal characteristics and genetic information. The results revealed that using genetic information that characterizes yield grade and marbling of animals to group cattle and to determine optimal days-on-feed can increase expected net returns.

One recent study also examined producers' stated preferences for genomic information (Boaitey 2017). Boaitey assessed the relationship between the cow-calf producers' private valuation of genomic information on feed efficiency and their bull purchase decision. He estimated the stated preference of producers by using the WTP approach. The analysis is performed in a multi-trait context including both conventional and genomic breeding information (i.e., birth weight, weaning weight, etc.) and cow-calf producer heterogeneity from different attitudes and farm practices. The results showed that WTP of cow-calf producers for obtaining genomic information is positive and cow-calf producers' valuation of conventional breeding technologies is relatively higher. Boaitey (2017) focused on feed efficiency, which is one of the most important production animal traits. However, in our study, we categorized 21 animal traits into three groups and estimated the valuation of cow-calf producers by using the willingness-to-accept (WTA) approach. More details associated with this approach will be discussed in chapter 4.

2.4. Agriculture Technology Adoption and Producer Decision Making

Caiazza et al. (2014) offered a new perspective on innovation in the agri-food industry. They stated that promoting innovations in the agri-food industry requires various forces interacting with each other, which involves a variety of institutions (i.e., private sectors, governments, and research organizations), actors (i.e., producers and innovators), and activities. Spielman et al. (2016) identified three interrelated components of agricultural innovations including discovery, development and delivery. Firstly, the discovery stage is the initiation of the scientific component of the innovation (Hall 2004). Then, the development process describes the translation of science into technology, adoption of this technology and commercialization. Delivery refers to the spread of this technology to the market (Spielman et al. 2016). This entire process of agricultural innovations is reflected by the adoption decisions made by individual farmers. The overall industry uptake of new technologies largely depends on calculating the benefits of these innovations in terms of profit.

Lalman and Smith (2001) examined the adoption of calf preconditioning by cow-calf producers. Specifically, the incentives for producers to adopt the program comes from the possibility to get premiums from other players in the supply chain. Based on the data available in this research, preconditioning significantly improved of the performance of a variety of animal traits, including reducing morbidity and mortality, and increasing weight gain and feed efficiency.

In some other industries, information sharing is based on the advanced information technology which focuses on providing the on time sharing between upstream suppliers and downstream participants. However, for the beef industry, the information sharing might not be about the sales of products and the types of products sold in a certain period. Instead, the performance of cattle in feedlot should be considered. In the previous part, elements listed by Amaya et al. (2020) are examples. Data about the growth weight in a period, milk production and age of first calving should be collected for the information sharing. With this kind of requirement, feedlot management system should adopt certain technology for recording the data of cattle and then to make the data to become useful information about performance of certain gene. In this circumstance, BAs and cow-calf producers should communicate for knowing what kind of information should be recorded and what kind of data is needed for making further genomic selection decisions. Based on the features of this industry and the purpose of information sharing, it can find that the effectiveness of the information sharing can be influenced by the cooperation between BAs and cow-calf producers. The system is not only decided by the technology used for collecting data, but is also decided by the elements involved for data analysis.

In conclusion, information sharing is a common behavior in different industries. Many different studies have figured out the benefits of genomic selection. The ultimate purpose of information sharing in beef industry is to increase efficiency for genomic selection and to increase economic value for the producers. In previous part, the benefits for both parties in the information sharing have been discussed. But for having the effective information sharing, the security of data, protection of commercial secret, types of information and other detailed issues should be identified. BAs and cow-calf producers should have a good communication with each other for achieving the agreement.

Chapter 3. Data Analysis

3.1. Introduction

This chapter describes the data collection, the pretest of online survey, variable expectations, and statistical descriptions and analyses. Especially in section 3.5, questions of "what do the sample producers look like?", "what kind of producers are more likely to involve in information sharing?", "who the producers are more likely to share information with?", and "what are their incentives?" are answered, respectively.

3.2. Data Collection

The primary data used in the empirical section is collected through the cow-calf producer survey (Appendix 1). This survey and research project have been approved by the Research Ethics Board (REB) at the University of Alberta (REB Project ID: Pro00090439). Information about the study, confidentiality, withdrawal, and benefits from the survey and the project are presented to respondents. The online survey was conducted with the help of Information Services & Technology of the University of Alberta between October of 2019 and January of 2020. It incorporates 24 questions related to the study and three additional questions that are used to collect participants' comments and contact information so that they can receive the final study report and the prize winner can be awarded. Each respondent received an equal opportunity to enter a prize draw of $100 steakhouse gift card, and eventually one of the participants won it. According to timing records, this survey takes 29 minutes to finish on average. The survey was designed to be completed within a reasonable amount of time in order to avoid a high withdrawal rate that is typically caused by an overly long questionnaire.

Since we did not have a contact list of available producers, I advertised the survey on a newsletter called *"Grass Routes"* which is run by Alberta Beef Producers. This newsletter is an online journal that is published every week and sent to beef producers by email. The link of our survey was included in three issues in total. Survey questions were designed in such a way that respondents had to complete all the questions on a page before they can move on to the next one. All respondents were over the age of 18 years and had to be commercial cow-calf producers to participate. Those who did not meet these basic requirements were screened out. The public link of the survey was not sent to better target my respondent pool. However, by using this approach, we were not able to recruit large number of respondents. During the period of administering the survey, I met some producers at the Farmfair International event (i.e., a regional agricultural farm show) where I administered the survey. In addition, we asked help from industry insiders and agricultural academies by sending them the link of the survey so that they can share it with their own contact list of commercial cow-calf producers. Unfortunately, only 52 respondents completed the survey eventually, which is far from the expectation of 100 to 150.

In order or test the functionality of our online survey, some people working in the beef cattle industry were invited in August of 2019 to conduct the survey before sending out to more commercial cow-calf producers. It includes industry stakeholders, such as BA executives and beef producers in Alberta. Some of them currently own, or have owned commercial cow-calf operations and some of them have family members who have commercial cow-calf operations. Participants were encouraged to point out any editorial mistakes or concerns about the survey, and they were welcomed to provide suggestions and corrections for any part of the survey. After pretest, many questions were changed and added according to their suggestions. This testing largely improved the questionnaire by increasing the clarity and accuracy of each question.

3.3. Variable Expectations

3.3.1. Operation and Demographic Questions

The survey began with a series of questions about cow-calf producer demographics and operation attributes. In this part of the survey, gender, age and education level of the primary decision-maker of each farm are asked. According to many studies (Jones 1963; Vanslembrouck et al. 2002; Sheikh et al. 2006; Edwards-Jones 2006), these factors are known to be important in the decision-making process at the farm level. Thus, in this study, I expect these demographic attributes to impact the decisions of commercial producers regarding collecting and sharing information with breeding associations and their willingness to accept compensation for collecting and sharing this information. In addition, this section gathers information related to operational decision-making by the respondent or other individuals related to the respondent.

Studies (Jones 1963; Potter and Gasson 1988; Edwards-Jones 2006) showed that characteristics of the farm household and the structure of the farm business, including farm type, farm size, and the work patterns of the spouse, are key elements that largely influence farm level decision-making. In addition, some specific factors, such as the bull replacement rate, that potentially impact the WTA of producers to share information are asked in the questionnaire. To determine the bull replacement rate, the survey asked the average number of breeding bulls and replacement bulls. The bull replacement rate for each farm can be calculated as:

Bull replacement rate = Number of replaced bull/Number of breeding bull * 100%

From this element, producers' perspectives on genetic rotation can be investigated. This may affect their decision on genetic information sharing. Moreover, question A11 asked the number of replacement bulls that are either bought from breeders or selected from their own herds. From these questions, producers' views on genetic investment can be inferred. Question A7 asked about other types of activities conducted on the farm, aside from cow-calf operations. The responses to all of these questions can help determine if the degree of integration impacts decision-making on information sharing. As mentioned earlier, the beef industry is not as integrated as other livestock industries. If the owners of different cooperated farms are not the same, information sharing is extremely difficult due to high transactional cost. On the contrary, if a cow-calf producer also owns a feedlot, it is easy for him/her to obtain some traits (e.g., yearling weight) since she/he records more data, even after weaning.

3.3.2. Current genomic information collection and utilization

In this section of the survey, the importance of each animal traits in the commercial farm practices was asked because this factor may impact the farmers' decisions when some of them behave as risk adverse and some of them behave as risk neutral. For example, if a producer is risk neutral, she/he is assumed to be willing to share all the information for free if the cost of information collection and transmission is zero. However, if she/he is risk adverse, she/he will potentially have a positive WTA for sharing the data. This is highly possible even when the collection and transmission cost is zero because she/he believes that certain economic risks may be incurred by commercial cow-calf beef producers resulting in a reluctance to share their animal trait information with BAs, or other supply chain actors like feedlots or packing plants. These risks could potentially be incurred by producers who may lose certain benefits caused by sharing private information with other players in the beef supply chain. Questions on how commercial cow-calf producers use and collect genomic information and their thoughts on sharing this information with others are asked in the survey. These factors directly influence the extra costs incurred by sharing information for each operation. Difficulty of collecting each animal trait data is investigated instead of asking them to gauge the potential cost of recording this data because it is hard for many commercial producers to estimate the cost. However, the difficulty level is relatively subjective and makes it hard to accurately express it.

In this section, the five-point Likert Scale format was used to present questions like "EPDs can be an important tool for animal selection, how important are the following animal traits for you when thinking about which animals (cows and bulls) to select (or not select) for breeding purposes", "how difficult is it for you to collect information on the following animal traits", and "how important are the following factors when deciding whether or not you are willing to share this information". Rating scales have been used in the social sciences from at least half century before, both as research tools and in practical applications (Matell and Jacoby 1971). This approach is helpful when we conduct stated preference surveys. The optimum number of rating categories is an interesting topic of concern (Garner and Hake 1951; Guilford 1954; Matell and Jacoby 1971). They found that the scale would be coarse if too few rating categories is used, whereas a scale that is too finely divided could be beyond the rater's limited powers of discrimination. Since there were similar surveys with the same format, we selected the five-point Likert Scales in this cow-calf producers' survey because it has enough discriminative powers and avoids fatigue for respondents during the questionnaire.

3.3.3. Incentives for Recording and Reporting Information

Before creating the survey, many people working within industry were interviewed, including general managers of different breeding associations, academics in livestock genetics related, and people who work in TrustBIX Inc., a third-party company that is working on information sharing among stakeholders in the beef industry.

Manafiazar (2018) who works at Livestock Gentec, an Alberta Innovates Centre based at the University of Alberta, stated that the reason for the lack of information transmission between commercial producers and breeding associations is that there is lack of linkage and motivation between them. If there is a third party (e.g., can be a company that providing products or services to commercial producers) who helps with recording and verifying data, they are connected. In addition, if commercial producers can get benefits from sharing their animal trait information, they will have the incentive to do so. When purebred breeders share their animal trait information with BAs, they can be rewarded or compensated by certain programs holding be Bas. For instance, Canadian Limousine Association has a Whole Herd Enrolment Program under which breeders are able to register their animals for $25 per head per year if they record and report all relevant data of the cow and her calves for that year (Verbeek 2018). They can also transfer their animals for free and there is no charge for genetic evaluations of the animals. Otherwise, the annual fee to register as Limousine cattle will be higher than $25, so this acts like a penalty for not recording and sharing data. However, this example provides an indication that monetary benefits can be used as the incentive for commercial producers to collect and share their animal trait information. Therefore, in the second section of the survey, we asked about the stated preference of commercial cow-calf producers to report different groups of animal trait information.

The positive WTA is expected in this study, and it is assumed that the WTA will be higher as the number of information types increase. For all three sub-questions in question B2, there are three categories of animal traits involved, including “health/diseases and maternal traits” (group A), “production/efficiency and parentage traits” (group B), and carcass traits (group C). These traits are categorized according to the expected degree of data collection difficulty, where group A consists of the most "easy-to-obtain" data, and group C has the "hard-to-get" data. As the respondents are all cow-calf producers who usually raise their cattle from birth to weaning, it is assumed that they can easily to collect maternal traits and record relevant health information during this period. For production/efficiency and parentage traits, it is assumed that the data collection difficulty highly depends on whether producers operate feedlot or finishing operations or whether they have close relationship with these farms. Therefore, it is relatively more difficult for them to obtain these traits in comparison to health/diseases and maternal traits. Twine (2014) pointed out that there exists some evidence of vertical integration between different production levels of cattle farms. While the backgrounding process is commonly carried out by cow-calf producers (Athwal 2002), some beef processors also own feedlot operations. However, there is little evidence that shows cow-calf producers also process animals. This leads to the assumption that it is difficult for cow-calf producers to collect and share carcass data. We asked the WTA of producers to share this animal trait information about group A, group A+B, and group A+B+C. Payment numbers are provided from $0 to $10 per head per year as hypothetical monetary incentives. This is much lower than an existing information sharing case of incentive scheme by the Canadian Beef Sustainability Acceleration (CBSA) pilot project ($16.21 per animal per quarter, on average; therefore, possibly more than $60 per animal per year). We believe these are reasonable payments. However, according to the telephone interviews with some general managers from BAs, BAs do not have large budget for gathering commercial data even though it can be valuable for them. In this case, we used lower payments in this study in order to achieve a more valuable reference for BAs in the future.

Stochastic payment card (SPC) design is utilized in the question about producer preference valuation (question B2). Lloyd-Smith & Adamowicz (2018) used this approach for private good WTA experiment. The SPC approach is closely related to the multiple bound discrete choice (MBDC), but it allows respondents to use both words and numerical values to express themselves more easily (Wang and Whittington, 2005). The SPC question used in the experiment included eleven payment amounts from $0 to $10 for information of one individual animal. More details will be included in the next chapter.

3.4. Data Description

3.4.1. Summary Demographic and Socio-economic Statistics

This section summarized the demographic and socio-economic statistics from the commercial cow-calf producers WTA survey. There are 52 completed surveys collected from respondents. It is hard to calculate the response rate because the link of the survey was posted on some online weekly newsletters, which is open to the public, but only advertised to cattle producers. In 2016, the census shows that there were over 12,000 cattle ranchers in Alberta. Compared to the total number, this sample size is not representative, but this is a convenience sample with low collection cost. In addition, this is less time consuming than large dataset. By using small sample, this study can refine this kind of research study before testing a larger and more representative sample. Table 3.1 demonstrates that about 80% and 20% of the respondents are male and female, respectively. Approximately 21% of the respondents are under 35 years old, about 38.5% of them are between 35 and 55 years old, and 40.5% are over 55. However, according to Statistics Canada (2011 and 2016) which is shown in the last two columns of Table 3.1, male producers accounts for around 70% of all producers in Alberta, and the percentage of young producers among all Alberta producers is much lower than what is represented by the sample. We expected that our sample can be representative of the general population of commercial producers, but it was difficult to obtain enough participants for a representative sample size that is close to Albertan producers in gender and age composition.

Table 3. 1 The Comparison of Gender and Age Composition between the Sample and All Alberta Producers (Source: Author's calculation and Stats Canada 2011 and 2016) (N=52)

Demographic Variables	Description	Frequency	Sample Percentage	2011 Stats Canada (Alberta)—All producers	2016 Stats Canada (Alberta)—All producers
Gender	Female	10	19%	29%	31%
	Male	42	81%	71%	69%
Age	Under 35	11	21%	7.5%	8.5%
	35-55	20	38.5%	43%	35%
	Over 55	21	40.5%	49.5%	56.5%

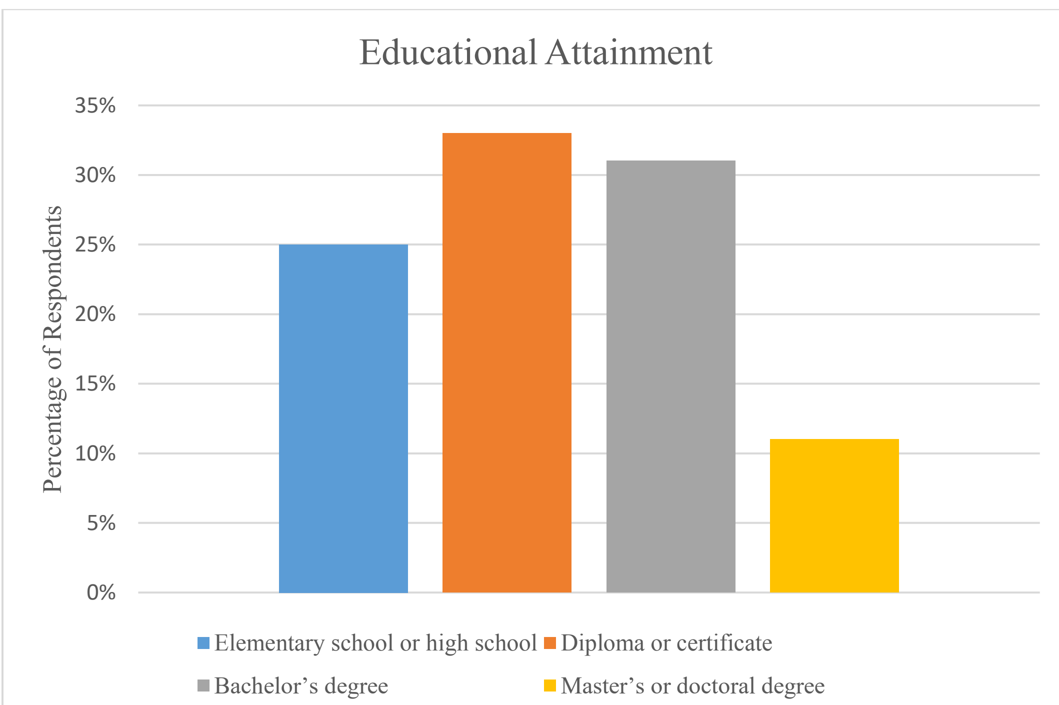

Figure 3. 1 Respondents in Different Education levels

According to Figure 3.1, respondents who have completed their elementary school or high school (only one respondent has not finished high school study) as their highest education level accounts for 25% of the sample. 33% of the respondents in the sample have obtained diploma or certificate as their highest education level, and 31% of them have been able to get bachelor's degree. Respondents with master's or doctoral degree as their highest education level accounts for approximately 11% of the sample.

As introduced in the last chapter, commercial cow-calf producers are not registered in any BAs. However, some of them are loyal to specific breeds and they change breeding animals due to the need of genetic rotation occasionally. Figure 3.2 shows the percentage for cow-calf producers in the sample using breeding animals from different breeds. Over 70% of the respondents expressed that they used Angus animals for crossbreeding, followed by Simmental and Red Angus, which have around 60% and 50% users, respectively.

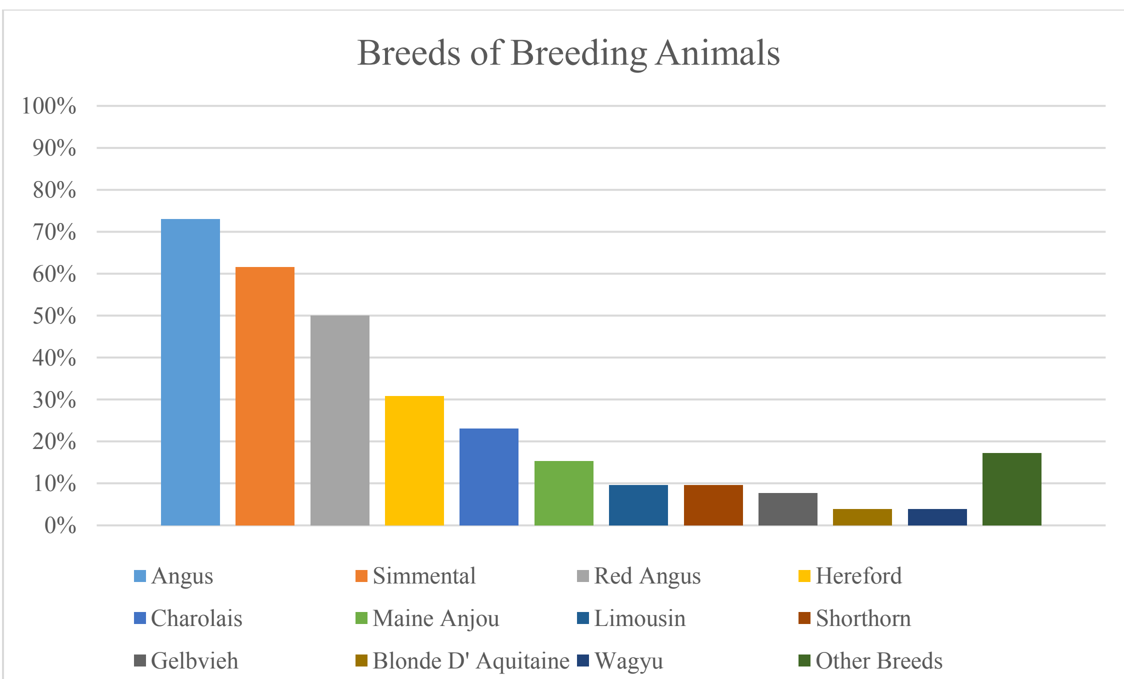

Figure 3. 2 Percentage of Respondents Using Breeding Animals (both bulls and cows) from Each Breeds

For respondents who answered the WTA survey, their average farm size is approximately 397 mother cows with a maximum of 6,800 and a minimum of 10 mother cows. The average number of mother cows for the past five years was used to measure farm size. This sample contains a wide range of farm sizes. Figure 3.3 shows the number of respondents for different ranges of farm size. Variable of the farm size in this thesis refers to the number of animals in the farm. The range is divided based on the respondent situation. Most of the respondents who took the WTA survey own a cow-calf operation with less than 250 mother cows. Canada's breeding herds range in size from five to ten cows on small mixed operations to several hundred or more on large ranches (Maclachlan and Stringham 2016). According to the survey, the average number of bulls is about 20 heads with a maximum of 2800 and a minimum of 1 head. One bull can typically breed with around 30 cows (Maclachlan and Stringham 2016).

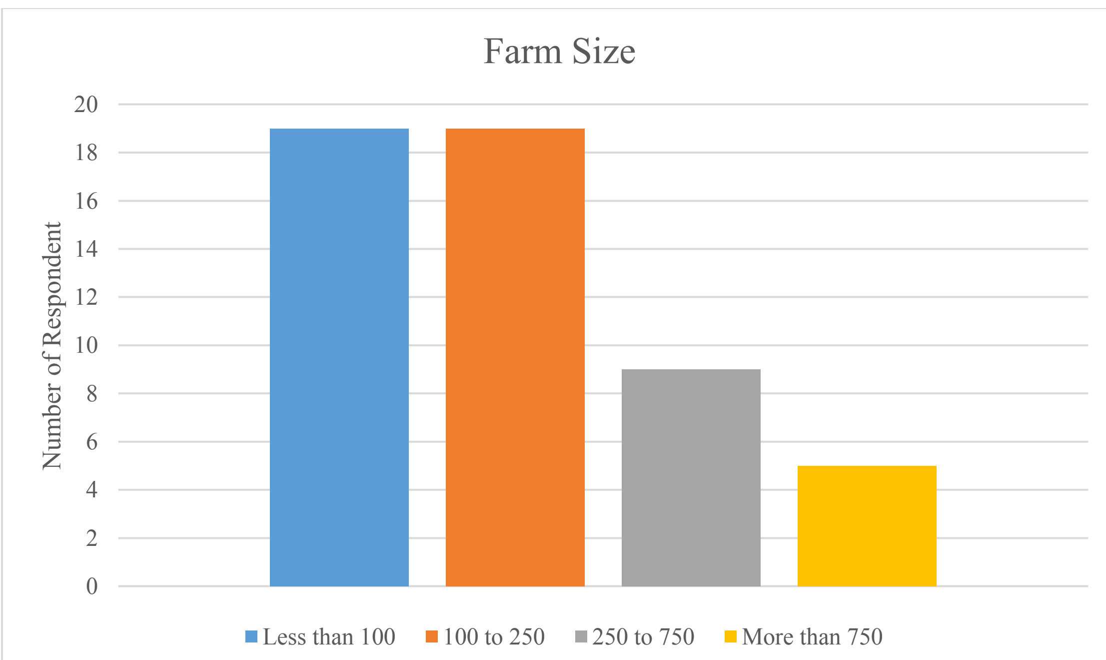

Figure 3. 3 Number of Respondents in Different Breeding Herds Ranges in Size of Mother Cows

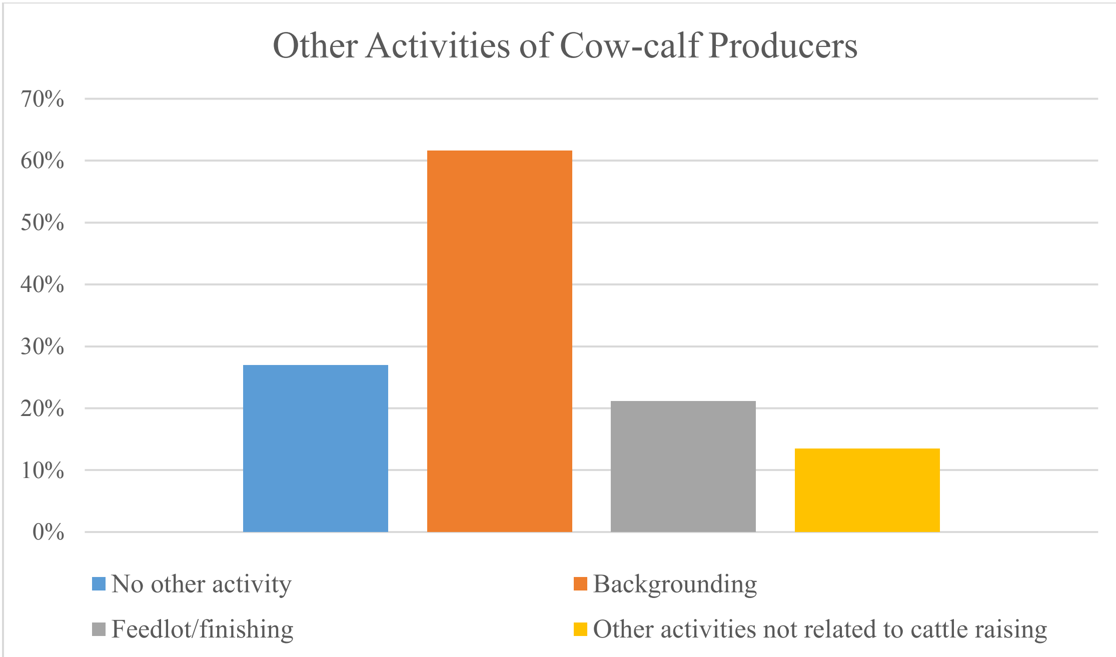

Figure 3. 4 Percentage of Respondents Who Conducted Each Activities Other Than Cow-calf Operation

Respondents were also asked about other activities that are conducted within their operations. According to Figure 3.4, about 27% of respondents reported that they do not have any other activity other than operating cow-calf farms, and 13% of producers have other activities not related to cattle raising. More than 60% of producers also have backgrounding operations, and over 20% of them own feedlots. No respondent in the sample owns a slaughterhouse or a packing facility. This reflects the integration level of each farm. For instance, if a cow-calf producer owns a feedlot operation, this farm is considered to have higher integration level than farms with only have cow-calf operations.

3.4.2. Statistic Summaries of Information Sharing

Figure 3.5 summarizes the current information sharing situation among all respondents. 69% of the respondents were not sharing animal trait information with any of the players in the beef supply chain, whereas only 31% of them were sharing information about their herds. However, more than 60% of the respondents who were sharing information cannot obtain monetary benefits. This implies that economic incentives are not the only potential helpful tool to implement information sharing. Some producers have shared their information without any monetary compensation. In the WTA survey, producers were asked to rate the importance level of different potential reasons that may explain their decision on sharing animal trait information or not. Except for cash compensation, there are other incentives motivate producers to share their information. Some producers want to obtain certification to help their operations to sell the animals for a premium. Some of them share information to get discounts for farm-level services. Some producers share information to show the quality and management to the market. There are producers believes information sharing can make the beef industry more competitive, which can benefit their own operations.

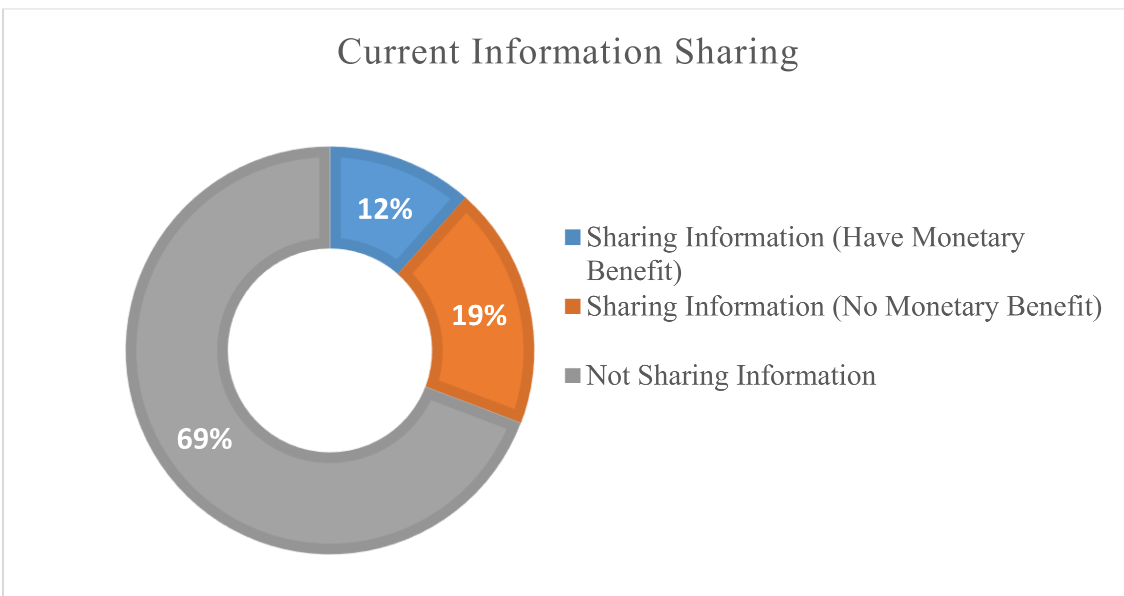

Figure 3. 5 Information Sharing Situation of Respondents

Respondents were required to answer questions about their willingness-to-share information at different payment levels (11 payment levels in total ranging from $0 to 10$). Instead of asking their decisions on sharing information at each payment level, the five likelihood levels were used to gauge how likely respondents would be to collecting and sharing different groups of animal trait information. This method is known as the Stochastic Payment Card (SPC) approach, which will be discussed in chapter 4. Figure 3.6 shows that almost 30% of the respondents are willing to share Group A information even without any monetary compensation. This message implies that if BAs can build connections with cow-calf producers, they could obtain animal trait information to improve genetics from around 30% of them even without paying them. Moreover, 85% of respondents were willing to collect and share Group A information at the highest compensation level ($10 per head per year) provided by the survey. As expected, when asked to share even more information, fewer respondents were willing to participate at the same compensation level. Also, in accordance with the expectations, fewer respondents were willing to accept for lower compensation. However, Figure 3.6 shows that approximately 15% of respondents are willing to collect and share data from all three groups of information with no monetary compensation. This is because, according to the survey feedback, producers expected to get certification or discounted services from sharing their information. Many of them believed that by sharing information they can advertise their farms or can get other information in return. Some of them just simply wanted to improve the beef industry by transmitting information along the supply chain. Figure 3.7 shows the percentage of respondents who rated "important" or "very important" for the provided reasons. Clearly, *"cash compensation"* is not the most important reason for both collected and non-collected data. Approximately 70% respondents believed that getting certification for their operation and obtaining information from other producers or BAs are more important than simply receiving monetary benefits. For most of the reasons, there is no significant difference when producers think about collected and non-collected information, except for *"benefiting the industry"*. It is understandable because producers need to collect data before sharing, and if there is no short-term benefit, it is hard to incentivize them to invest for the whole industry.

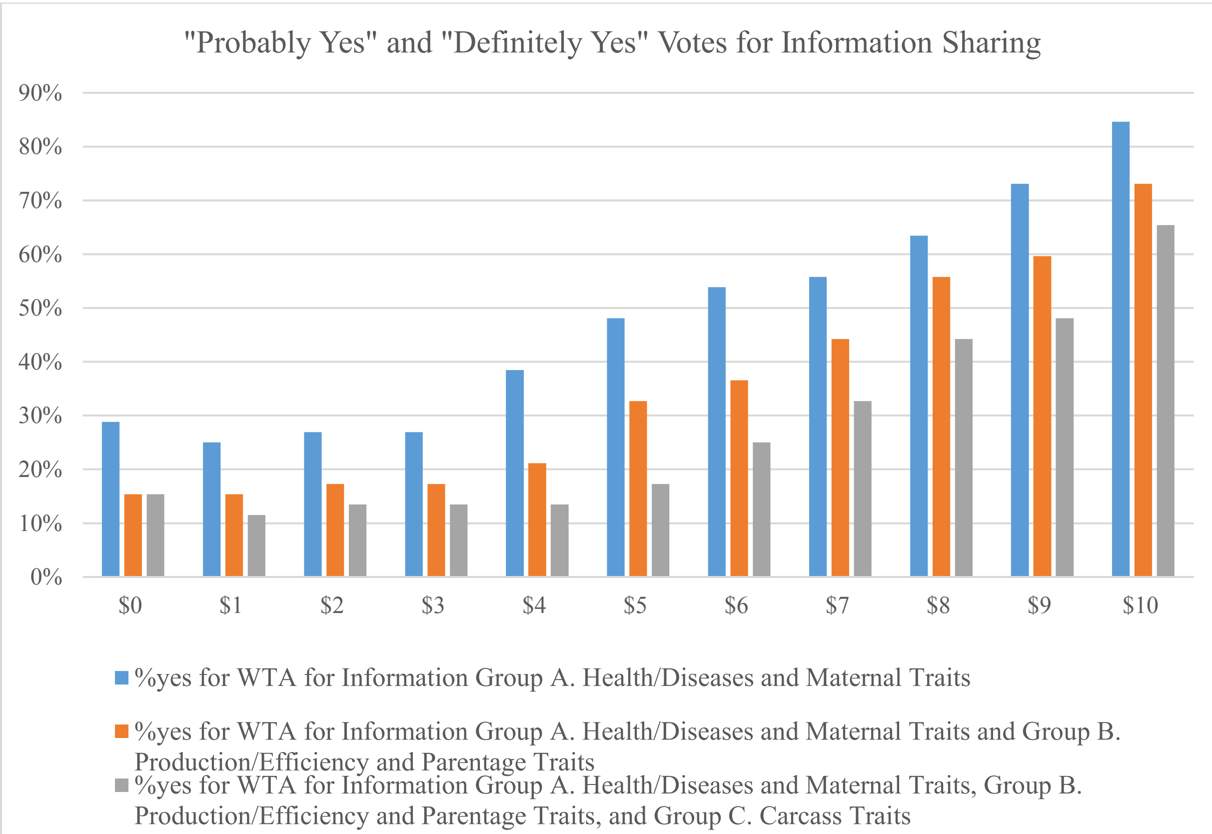

Figure 3. 6 Willingness to Share Information at Different Cost Levels

In chapter 2, it has been demonstrated that demographic variables could impact farm level decision-making. According to the sample, we can conclude that male producers and younger producers are more likely to engage in information sharing (Figure 3.8-3.9. The sample does not suggest that educational attainment have an influence on the willingness to share information, but the respondents who studied agriculture or genetics related majors were more likely to share information. Figure 3.10 shows that approximately 50% of respondents with degrees in other subjects voted “probably yes” or “definitely” yes in regards to sharing information, regardless of the type of animal data that is being shared. This implies that producers with degrees in other subjects were not as sensitive as producers with degrees in agriculture or genetics related majors when asked to collect and share different types of animal trait information. Several reasons can explain this result. First, it is possible that producers with non-agriculture/genetics related degrees are less knowledgeable about the differences among animal traits. Second, this can be influenced by other variables, such as farm size and the integration level of operations. Another interesting statistic from Figure 3.10 is that 89% of respondents who have degrees in agriculture or genetics related majors are willing to share maternal traits and health/disease information of their animals. This is a helpful signal for BAs to conclude that producers with degree in related majors are more likely to share information, which meets our expectation.

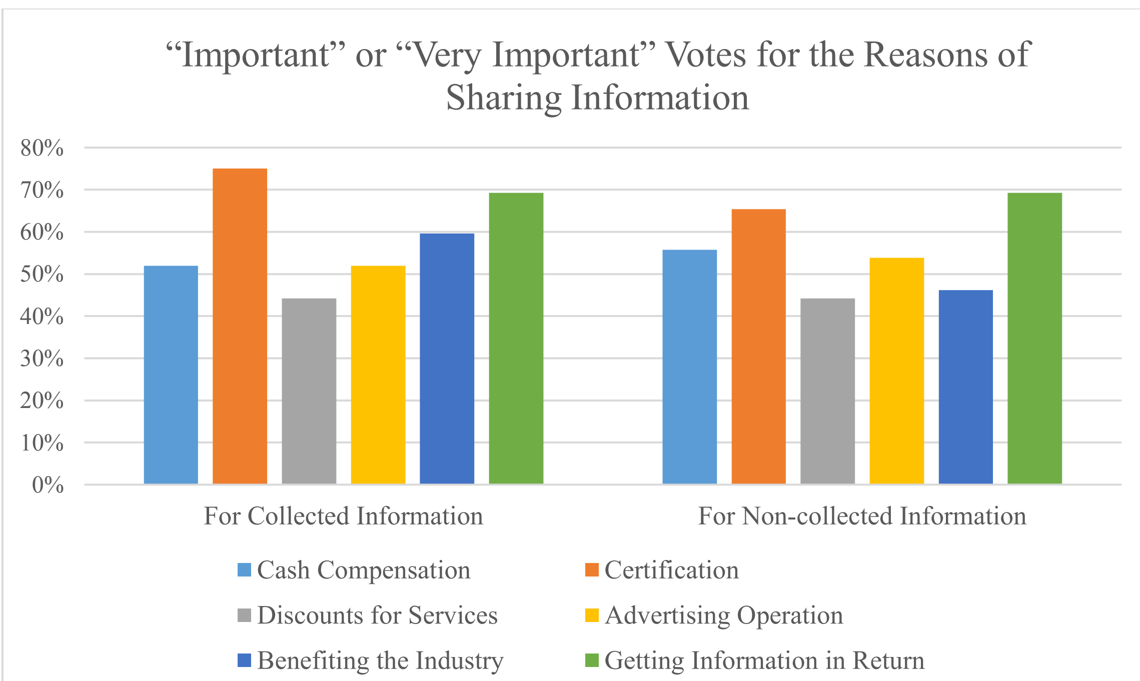

Figure 3. 7 Importance of Different Reasons to Share Information

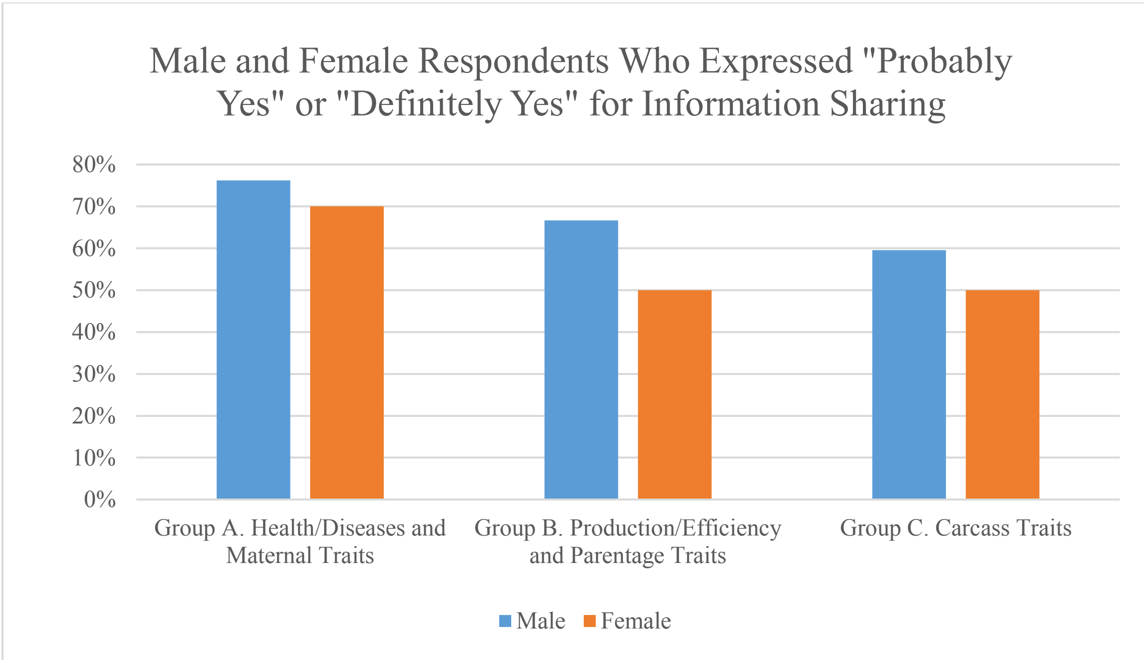

Figure 3. 8 Gender and Willingness to Share Information

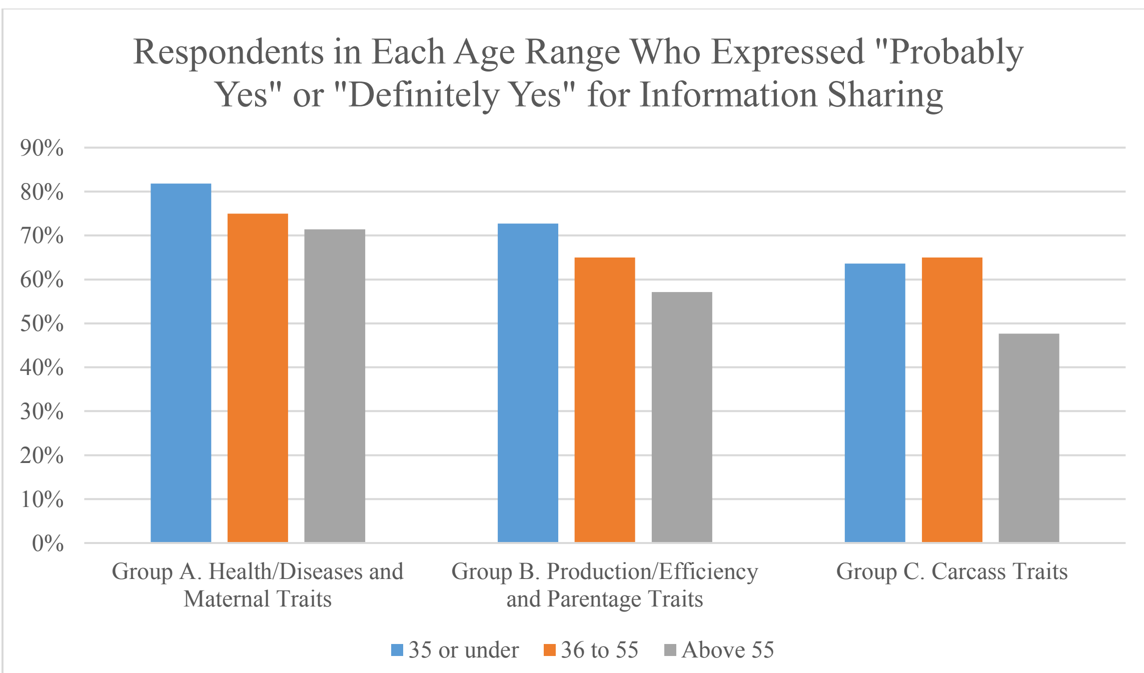

Figure 3. 9 Age and Willingness to Share Information

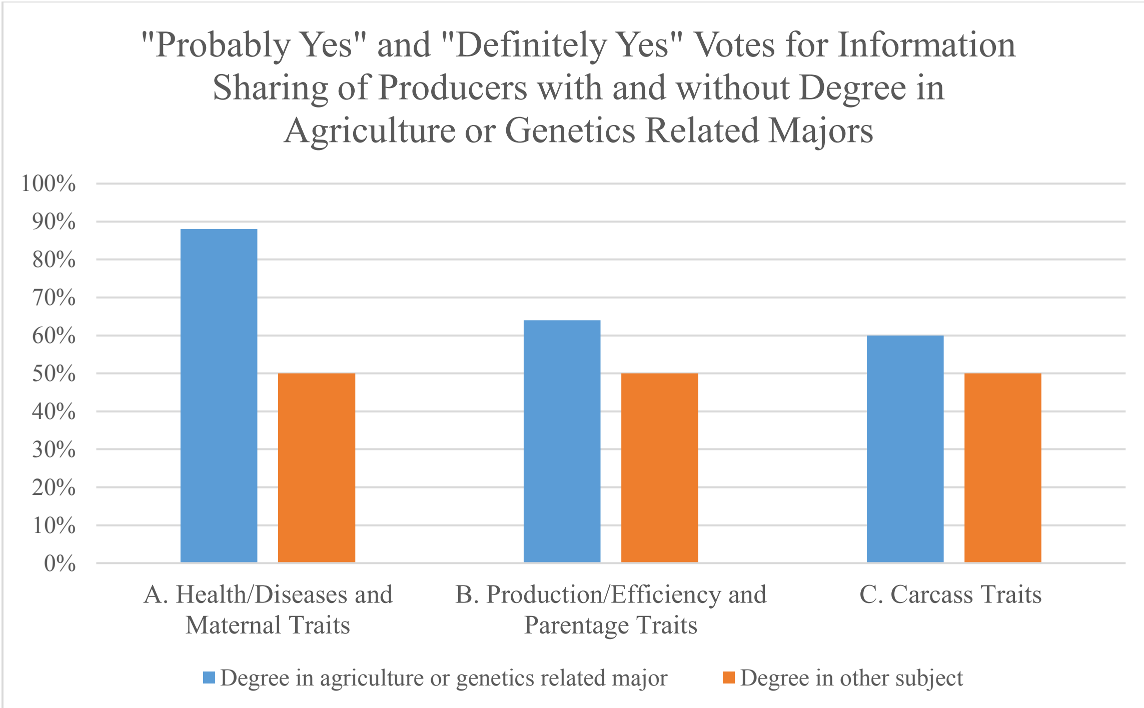

Figure 3. 10 Education Background and Willingness to Share Information

Angus, as the biggest BA in North America, has strongly invested in genomic information collection. Therefore, we expected that Angus and non-Angus producers may have different points of view on collecting and sharing information. In our sample, 25% of Angus producers expressed that they have been involved in information sharing, compared to only 6% of non-Angus producers (Figure 3.11). Figure 3.12 compares the percentage of Angus and non-Angus producers who are willing to share different types of information with $10 or lower compensation. We find that fewer Angus producers will change their decisions to "no" when respondents are asked about the willingness to share more data including carcass data. This implies that Angus producers are more likely to access carcass information than non-Angus producers.

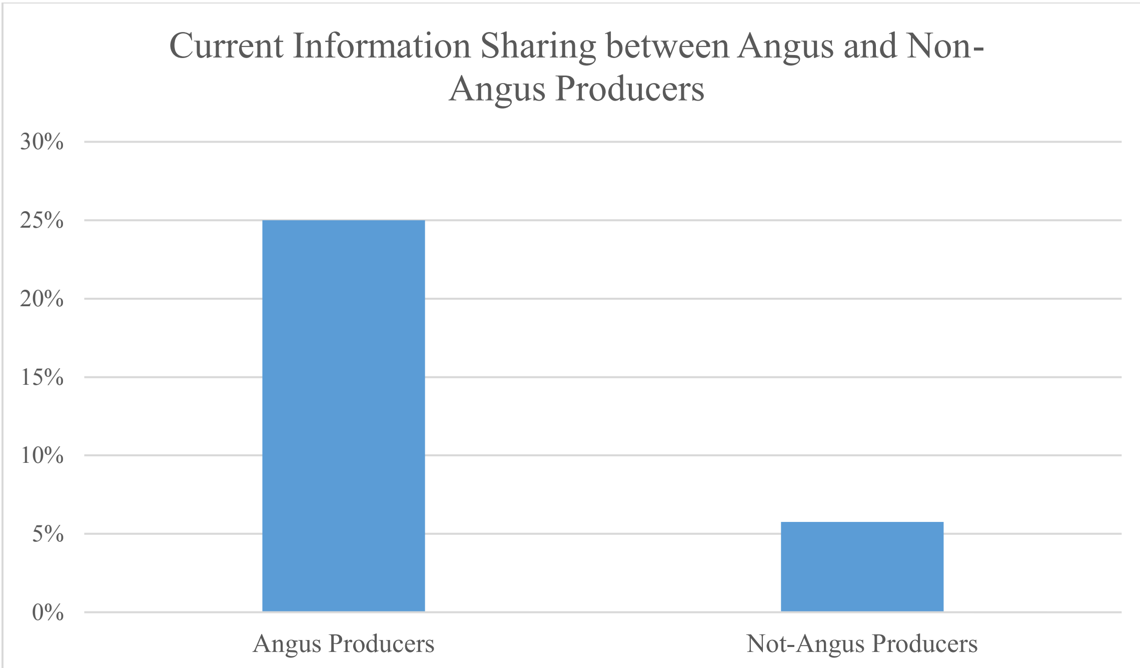

Figure 3. 11 Type of Producers and Willingness to Share Information

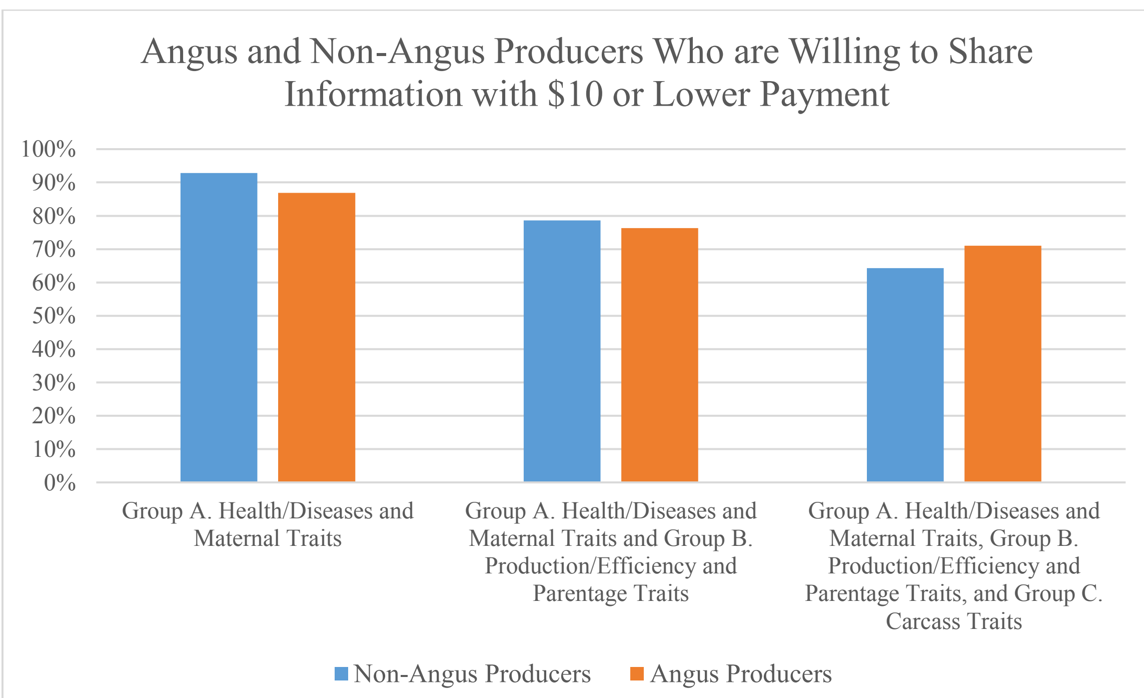

Figure 3. 12 The Comparison of the Percentage of the Producers Who are Willing to Share Different Types of Information with $10 or Lower Payment between Angus and Non-Angus Producers

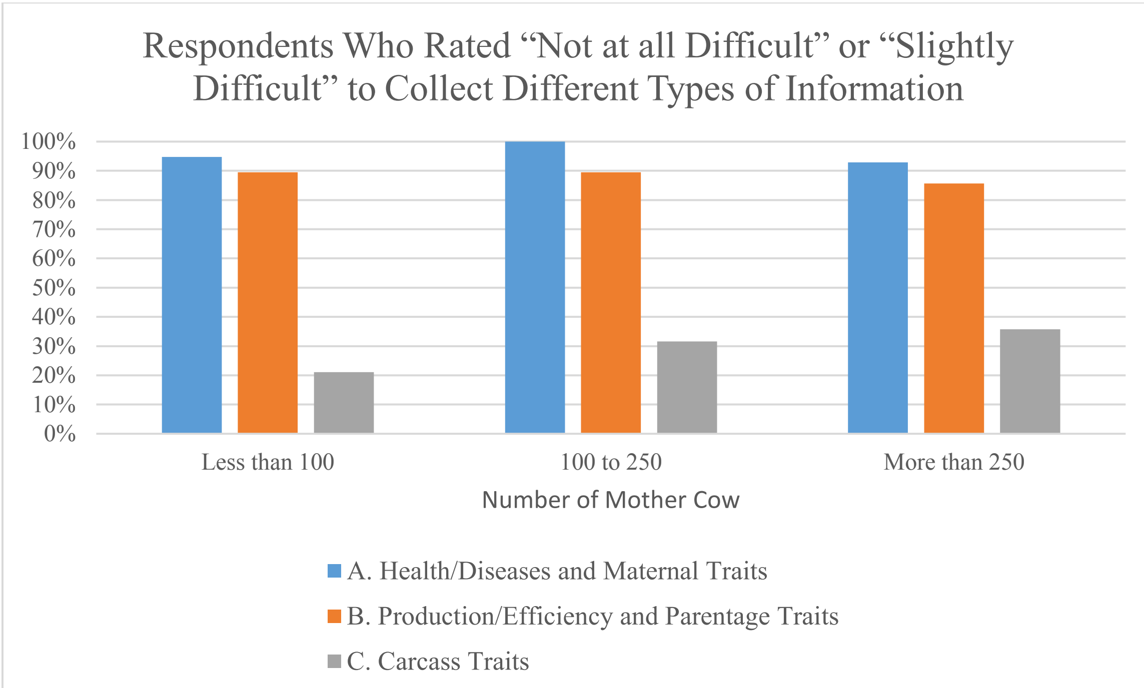

Figure 3. 13 The Comparison of the Percentage of Respondents Who Rated "Not at all Difficult" or "Slightly Different" to Collect Animal Trait Data in Each Group among Operations with Different Sizes

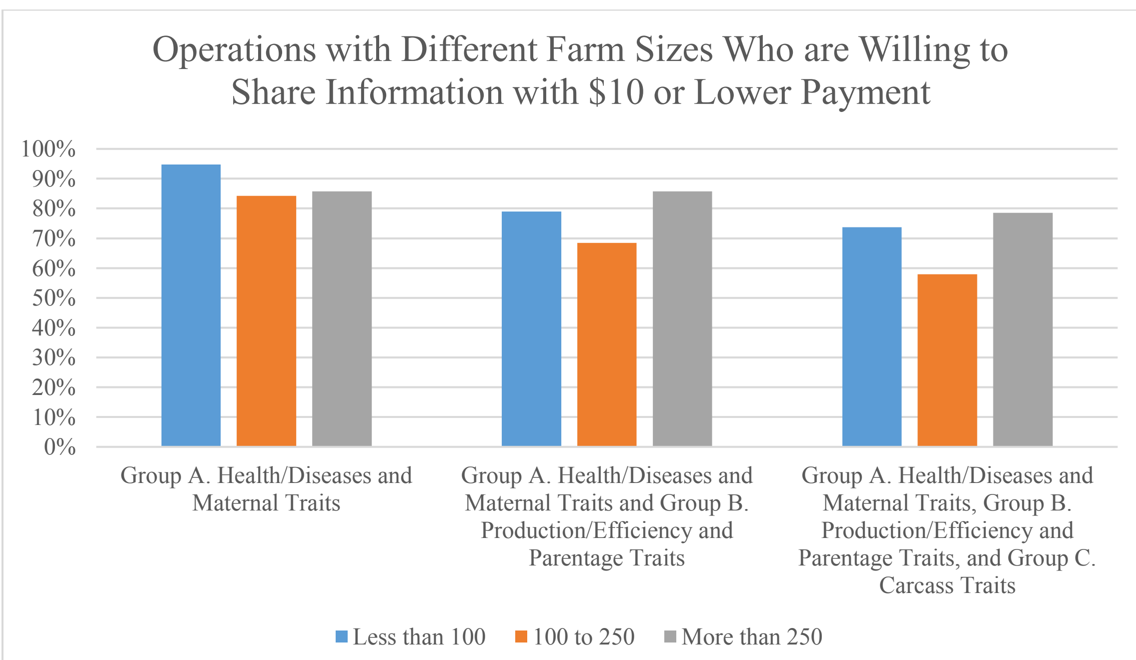

Figure 3. 14 The Comparison of the Percentage of the Producers Who are Willing to Share Their Information with $10 or Lower Payment among Operations with Different Farm Sizes (Number of Mother Cow)

Table 3. 2 Correlations of Farm Size (with the Difficulty Level of Collecting Information in Each Group of Animal Traits and the Willingness to Sharing Information in Each Group of Animal Traits)

	Difficulty Level of Collecting Information	Willingness to Sharing Information
Group A. Health/Diseases and Maternal Traits	0.12	-0.29
Group B. Production/Efficiency and Parentage Traits	0.11	-0.28
Group C. Carcass Traits	-0.09	-0.14

Before sending out the survey, it is assumed that farm size can be a strong variable that can the influence producers' decisions regarding animal trait information sharing. It is potentially easier for small farms to collect data because they have less animals to operate. It is also possible that it is cheaper for larger farms to measure phenotypic data due to their economies of scale. However, in accordance with the data from Figure 3.13, there is no obvious difference for respondents with different farm sizes for collecting information on animal traits in group A and B, which is contrary to the assumption. Even though correlations shown in table 3.2 suggest that information in group A and B is less difficult to collect for small operations than large operations, the correlations are too weak to show the relationship. If we look at the "grey bars" in Figure 3.13, only 20% of the small farms (less than 100 mother cows) said it was easy for them to record carcass data, whereas over 30% of medium (100 to 250 mother cows) and large (more than 250 mother cows) farms rated "not at all difficult" or "slightly difficult" to collect carcass data. However, the correlation in Table 3.2 shows a negative weak relationship between farm size and the difficulty level of collecting information. More interestingly, as farm size increases, the primary decision-maker is less willing to share their information (Figure 3.14). Correlations on the second column in Table3.2 confirms this relationship. For carcass data, Figure 3.14 and the weak correlation both imply that the size of cow-calf operation does not impact the willingness to share carcass data. However, this may be caused by the small sample size.

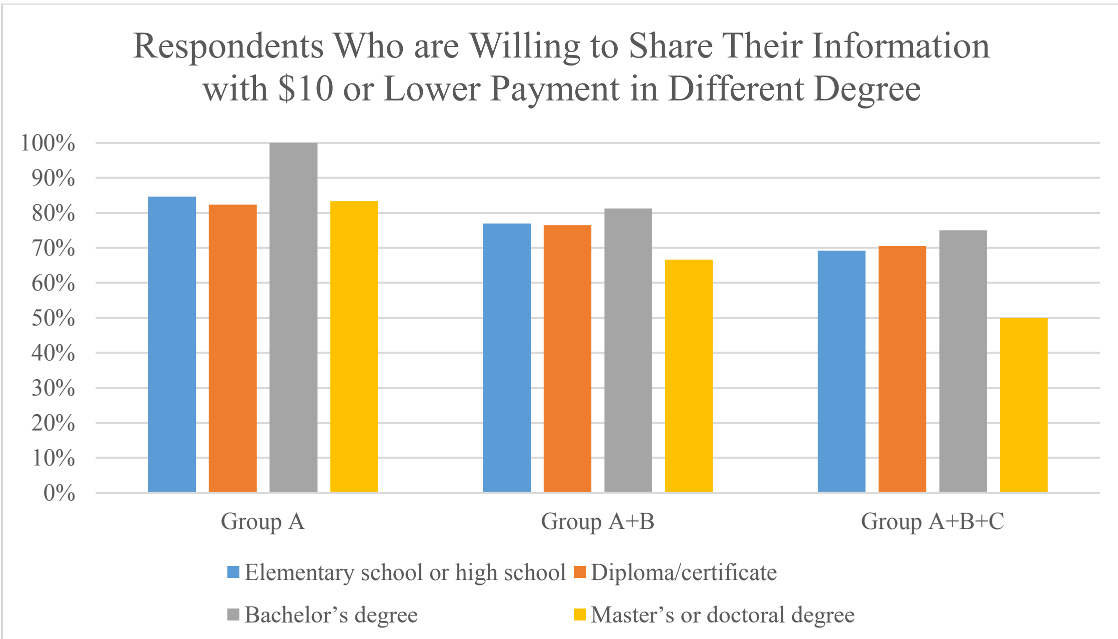

Figure 3. 15 The Comparison of the Percentage of the Producers Who are Willing to Share Their Information with $10 or Lower Payment among Different Degrees

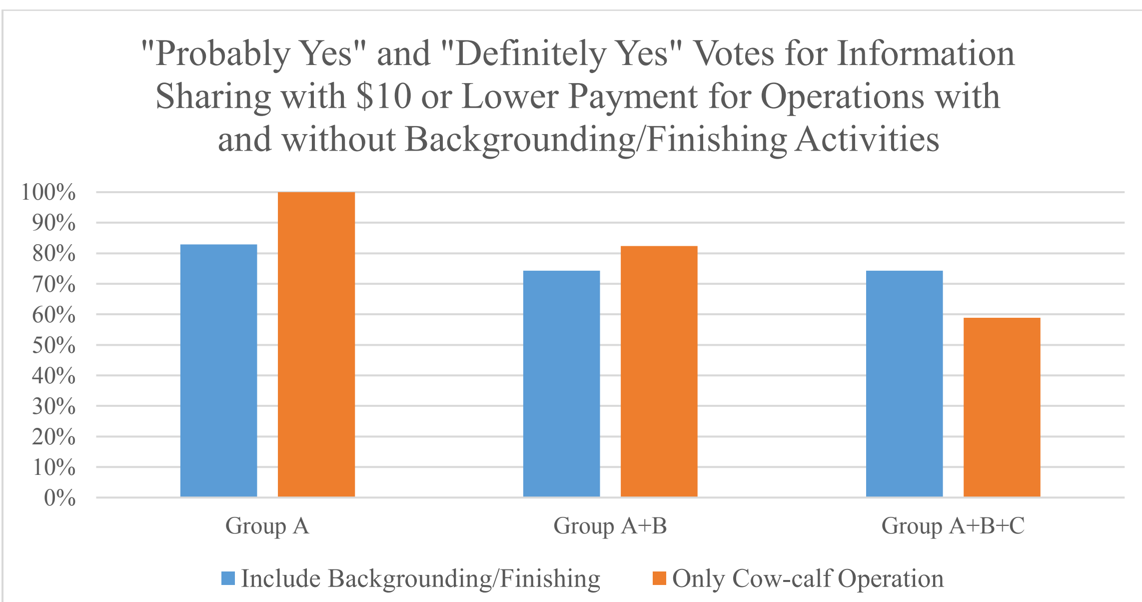

Figure 3. 16 The Comparison of the Percentage of Respondents Who are Willing to Share Their Information with $10 or Lower Payment Between Operations with and without Backgrounding/Finishing Activities

There is no obvious relationship between the willingness to share information and the level of education (Figure 3.15). However, as shown by Figure 3.16, there is an obvious drop in the percentage of respondents for operations that only have cow-calf activity ("orange bars"), but the difference among the percentage of respondents for operations that include both cow-calf and backgrounding/finishing activities is relatively small ("blue bars"). One potential reason is that producers who only have cow-calf operations care more about the ease with which they can obtain the information that they are contemplating to share, and the amount of compensation required for them to share this information. On the contrary, the percentage of respondents for operations that include both cow-calf and backgrounding/finishing activities did not change a lot when asked for their willingness to share more information. This might be because these producers can get Group B information and Group C information easier than others, so that their expectation of payment is relatively constant. Figure 3.16 also demonstrates that 100% of producers who only operate cow-calf farms were willing to accept $10 or less per head of animal per year to share Group A information. When asked to collect more information, more than 70% of respondents from both groups were willing to share Group A+B information with $10 or lower compensation. However, the percentage of respondents who only operate cow-calf farms dropped more than 20% when asked to share Group A+B+C information. To conclude, for BAs that aim to improve maternal trait estimations, it is easy for them to gather commercial data if they are willing to pay producers at most $10 in compensation. However, if they are also looking for carcass data, it is better for them to build relationships with producers who operate both cow-calf and backgrounding/finishing operations.

While I have mainly emphasized and discussed the type of producers who are more likely to share information. It is also interesting to explore with whom the producers prefer to share their information. Figure 3.17 summarizes the number of producers who responded "important" or "very important" for each information source that are provided in the survey. Over 40 respondents believe that information from seedstock providers is important for them to assist with their breeding and genetic selection decisions. The second and third most important sources of information are other producers" and "friends/family who are experts in genetics", which are selected as important by 38 and 30 respondents, respectively. These numbers imply that producers trust the persons who are close to them, such as their seedstock providers, neighbor producers, families, and friends. Therefore, it is important for BAs or other stakeholders in the beef supply chain to nurture their relationship with commercial cow-calf producers, if they want to obtain information from them.

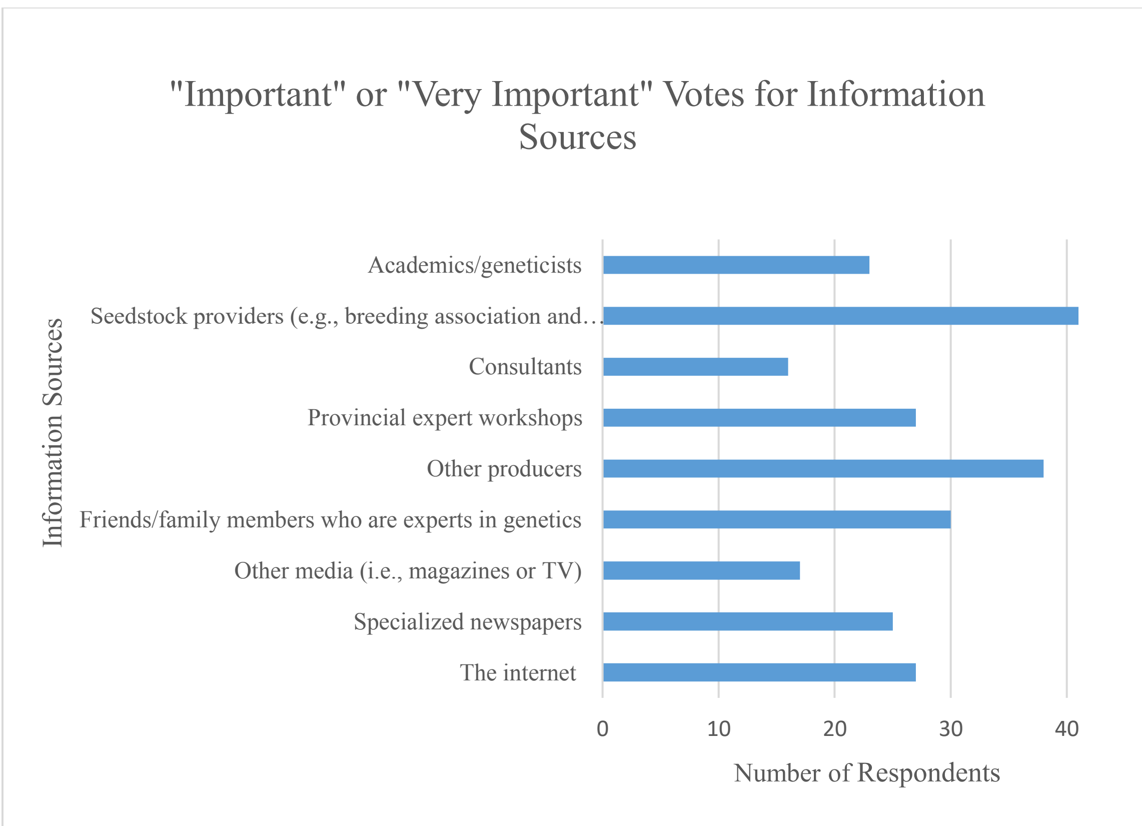

Figure 3. 17 The Number of Producers Who Responded "Important" or "Very Important" for Each Information Source for assisting with their breeding and genetic selection decisions

Table 3. 3 Correlations of the Willingness to Share Information

	Difficulty Level of Collecting Data for Selecting Animals	Importance Level of Animal Traits When Selecting Breeding Animals
Willingness to Share data	-0.27	0.30

Labor hours, monetary investment on measuring and recording tools, and advanced technologies are important factors for producers in collecting animal trait information. However, for most respondents, they have not recorded many of the animal trait data in the questionnaire, so it is very hard for them to estimate the cost of information collection. Therefore, instead of asking the investment for collecting data, this survey has focus on "How difficult is it for you to collect information on listed animal traits?" This provides an easier method to observe the expectations of respondents on the potential costs of recording data. As shown in Table 3.3, for cow-calf producers, if the animal trait information is more difficult to collect, producers are less likely to be willing to share this information. Figure 3.18 compares the percentage of respondents who are either willing or not willing to share different groups of animal information based on whether this information is "difficult" or "not difficult" to collect. It is expected that producers who believe that the information is not difficult to collect will be more willing to share without cash compensation. For example, for information of group A (health/disease and maternal traits), more than 33% of the respondents who said group A information is "not difficult" to collect are willing to share the information without cash compensation, and around 22% of the respondents who rated group A information is "difficult" to collect are willing to share the information without cash compensation. Almost 20% and 7% of the respondents are not willing to share the information even with $10 cash compensation when this information is "difficult" and "not difficult" to collect, respectively. This difference is also shown in information group A+B (health/disease and maternal traits, and production/efficiency and parentage traits), and information group A+B+C (health/disease and maternal traits, production/efficiency and parentage, and traits carcass traits). In addition, in the last part of Figure 3.18, for information group A+B+C, there is a greater difference in the "orange bars" and "grey bars" between respondents who rated carcass data is difficult and not difficult to collect. This means that when producers are asked to share carcass data, the willingness to share information highly depends on the difficulty level of collecting carcass data.

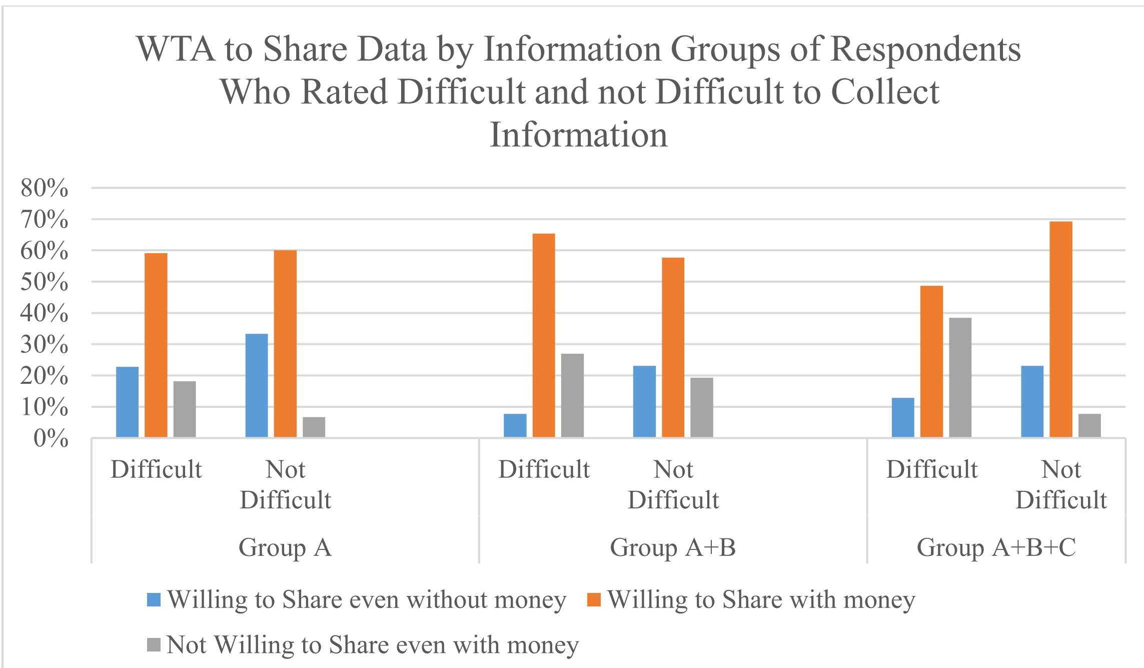

Figure 3. 18 The Comparison between the Percentage of Respondents who Rated Difficult and not Difficult to Collect Information When They are Ask for Their Willingness-to-accept to Sharing Information in Different Information Groups

Table 3. 4 Correlations of Bull Replacement Ratio and the Importance Level of Different Group of Information Rated by Respondents When They Make Decisions on Their Willing-to-share Information

Correlation with the Importance Level of Information Group A	Correlation with the Importance Level of Information Group B	Correlation with the Importance Level of Information Group C
0.13	0.10	0.14

Table 3. 5 Correlations of Bull Replacement Ratio and the Level of Willingness to Share Different Group of Information Rated by Respondents

Correlation with the Willingness to Share Information Group A	Correlation with the Willingness to Share Information Group B	Correlation with the Willingness to Share Information Group C
0.01	0.03	0.01

Usually, one bull can breed around 30 cows (Maclachlan and Stringham 2016). Well-defined breeding objectives prior to selecting breeding animals is important for commercial producers in extracting value from the investment in genomics by seedstock producers (MacNeil 2016). Producers replace their bulls each year for better genetics and for genetic rotation, or in other words, for different breeding objectives. *Bull Replacement Ratio* in this study is calculated by dividing the average number of replaced bulls in the past five years by the average number of bulls used for breeding in the past five years. Theoretically, higher bull replacement ratio suggests that the producer cares more about genetic rotation or gene diversity when she/he selects breeding animals. Table 3.4 presents the correlations between bull replacement ratio and the importance level of each information group when producers make decisions on information sharing. As presented, there were three positive coefficients listed, which suggest that producers who replace their breeding bulls more frequently are more likely to care about selecting different types of animal traits, and there is no obvious difference among types of animal traits. Table 3.5 shows the correlations between bull replacement ratio and the willingness to share information in different groups. All three coefficients are weak positive correlations. This is not surprising. Producers who have high bull replacement ratios invest a lot in purchasing breeding animals and care about genetic diversity and genetic information. Therefore, they are willing to share information used for genetic selection so that they can purchase breeding animals with more accurate and more stable EPDs. This can bring them more profit in the future.

3.5. Conclusion

Based on the survey data analysis, I find that the willingness of cow-calf producers to share information with BAs can be impacted by many different elements. According to the findings in the survey data, some elements have a positive influence on the information sharing behavior of commercial cow-calf producers. These elements are educational background, size of farms, type of the producers, bull replacement and the amount of monetary compensation to the cow-calf producers for information sharing. From the survey, it can find that some type of producers might have a higher willingness to share information, such as the one who have the educational background related to agriculture or genetics because they can know better about the importance of information sharing in farm operation. Also, some producers might seek for the information about breeding or related data from some individuals they know. It can state that producers have the demand of getting certain information or genomic data support from BA. However, the research result also showed that producers might have different attitude for different types of information. The more difficult to collect certain information, the lower level of willingness will be found among producers. In this study, the information types have been divided into three groups. If it needs the producers to spend a lot of time or energy for collecting certain data, they might not be willing to do such a work for the BAs. Even BAs provides certain compensation for them, they might not be willing to collect complicated information.

To sum up, age, gender, and study area of the primary decision makers, farm size, breeds of breeding animals, and whether involving backgrounding/finishing activities are potential factors that may impact the WTA for producers to share information. Producers tend to share information with people who are close to them, such as their own Bas/seed providers, as well as neighbor producers. In terms of the incentives for them to share information, cash compensation is a helpful but not the only benefit that can attract producers. Certifications, information of other players in the beef supply chain, and simply making the beef industry better off can also incentivize many producers. Moreover, the difficulty of collecting information and the importance level of animal traits when producers are selecting breeding animals can influence the WTA of information sharing as well. Bull replacement ratio should be an influential variable to explain producers' willingness to share information. In another word, producers have the demand of sharing information with BAs. For BAs that target to improve maternal trait estimations, it is easy for them to gather commercial data if they are willing to pay at most $10 compensation for producers. However, if they are also looking for carcass data from commercial producers, it is better for them to build relationship with producers operate backgrounding/finishing operations.

Chapter 4. Methods for Assessing Willingness-to-accept of Commercial Cow-calf Producers for Sharing Animal Trait Information

4.1. Introduction

This chapter discusses the methods for assessing the willingness of commercial cow-calf producers in Alberta to share their animal trait information. The main empirical approach involves estimating the willingness-to-accept (WTA). In order to observe the producers' WTA, a stochastic payment card (SPC) approach is used in the WTA survey. Data collected from the survey is used to estimate random effects logit models, which will also be described in this chapter. As described in previous chapters, a WTA survey of Alberta cow-calf producers was implemented online with a total of 52 surveys completed. In this chapter, the WTA approach will be compared with the willingness-to-pay (WTP) approach as both methods are commonly used to evaluate the stated preferences of respondents.

4.2. Willingness-to-accept (WTA) Approach

Studies (Ahlman et al. 2014; and Martin-Collado 2015) have evaluated the preferences of livestock producers regarding different animal traits, more commonly for production traits of bulls (Boaitey 2017). When evaluating a producer's preferences for animal traits, revealed and stated preference methods are both used by economists.

Revealed preference approaches reflect what people actually pay, while stated preference approaches reflect what people say about their willingness. For example, the hedonic price method, which is one of the revealed preference approaches, is about the regression of the price of an animal on selected traits which capture actual or/ and expected performance (Dhuyvetter et al. 1996; Dhuyvetter et al. 2005; Chvosta et al. 2001). Furthermore, there are different independent variables for different methods.

The hedonic price model has been used by cattle producers to evaluate implicit values for animal traits. The implicit value of each animal trait is represented by its coefficient in the models (Ladd and Martin 1976; Boaitey 2017). Dhuyvetter et al. (1996) used the hedonic price model approach to estimate the implicit values of the bulls' physical and genetic attributes, performance characteristics and marketing factors. This study included 1,700 bulls in 7 breeds, and found that there are varying effects of performance and physical attributes on bull prices from different breeds. Chvosta et al. (2001) extended this model by adding output (i.e., futures contract of feeder cattle) and input (i.e., corn) price expectation effects into the function, and found that both expected progeny differences (EPDs) and simple production function measures have statistically significant effects on the valuation of bulls by cow-calf producers. These effects were consistent across different breeds of cattle. One of the main weaknesses of the hedonic price approach is collinearity between different animal traits. In addition, it can only be used in perfectly competitive markets. Some studies (Vanek et al. 2008; and McDonald et al. 2010) have attempted to solve this issue by applying data pooling methods to combine both stated and revealed preference data. However, this approach also has limitations related to the absence of actual bull purchase data for specific bull traits such as feed efficiency (Boaitey 2017).

When revealed preference data is not available, livestock producers might use another approach which involves a group of techniques that use i^{th} respondents' beliefs regarding what they would do instead of actual behaviours to estimate their utility functions (Kroes and Sheldon 1988). This group of techniques is called the stated preference approach. With this kind of approach, the model for performing the analysis would be decided by the components of what respondents stated.

Petrolia and Kim (2011) conducted a contrast analysis between WTP and WTA of the value of coastal wetlands in the State of Louisiana of the USA. They estimated compensating surplus and equivalent surplus welfare measures for the prevention of future wetland losses. According to their study, WTP represents the amount of money that people are willing to pay to prevent expected future coastal wetland losses, and WTA is the monetary compensation that people are willing to receive to compensate for the wetland losses. By contrasting these two payment vehicles, Petrolia and Kim (2011) stated that there is more confidence in the reliability of the WTP approach compared to the WTA approach. Economically important factors, such as individual income and age, are only significant in the WTP model. Moreover, the WTP approach has been much more widely used compared to the WTA approach. In the Environmental Valuation Reference Inventory (EVRI) database, the number of WTP studies is 14 times greater than the number of WTA studies. One reason for this discrepancy may be that WTA responses lack incentive compatibility (Haab and McConnell 2002). Tunçel and Hammitt (2014) demonstrated the consistent gap between WTP and WTA from 76 studies. Martín-Fernández et al. (2010) introduced a WTA/WTP ratio to study patient perceptions of the service provided by their family physician. The authors utilized the contingent valuation method and a payment card approach to measure the WTP and the WTA. An explicative model was conducted to assess the WTA/WTP ratio. Eventually, they found that the WTA/WTP ratio is significantly influenced by age, income, and some other demographic characteristics. They concluded that respondents who were older and had a less favorable socioeconomic situation had a higher ratio when valuing a visit to their family physician. In other words, these respondents are more averse to a loss than attracted to a gain, which is referred to as “aversion to loss”. Other papers have also indicated that the degree of loss aversion could be different by some demographic factors such as gender, education, income, and culture (Booij & van de Kuilen 2009; and Booij et al. 2010). Therefore, WTP values are generally lower than WTA values. However, some studies have also found no significant gaps between WTP and WTA measures, such as List (2011).

Lloyd-Smith & Adamowicz (2018) showed that there is consistency between using WTP and WTA approaches when analyzing stated preference data for the valuation of private and public goods. Their results showed that the incentive compatibility of the WTA method is valid for public goods if responses have consequences for respondents. In addition, strategic behavior is present that is consistent with theory, and survey framing and follow-up questions are useful for the value estimation. More studies have used the WTA approach to evaluate producer preferences in the past decade. Cao et al. (2012) assessed the WTA compensation with the use of contingent valuation to estimate the value that herder families place on the livestock numbers that lead to overgrazing. Schulz et al. (2013) used a discrete choice experiment method to assess the farmers’ WTA of “greening” agricultural policy. Nevertheless, these models are not the same and the choice between WTP and WTA is not a random decision made by researchers. There are some studies that have demonstrated the determining or influential elements for choosing the appropriate model. According to Sindermann et al. (2022), people might prefer WTA to WTP when they choose a certain platform. It is said that people are willing to accept money or other benefit from a particular activity rather than paying for the activities. Furthermore, in the study by Luo, Swallow and Adamowicz (2022), farmers in Alberta, Canada, might have a small value gap between WTP and WTA regarding land conversion from agriculture to developed uses.

However, small value gap can still show a preference for WTA. Therefore, the WTA model is selected in this article.

4.3. Stochastic Payment Card Approach

Wang (1997) argued that uncertainty is an inherent characteristic of an individual's economic valuation. There are several sources of uncertainty related to an individual's valuation process. First, it may exist because the commodity or service is not well described. Second, respondents may not completely understand what the commodity or service means to them and/or have different ideas of what the good or service entails. Third, uncertainty can exist in the markets themselves. For example, a financial crisis may affect an individual's valuation process. Fourth, people may have different characteristics and preferences which may result in uncertainty. This uncertainty is not likely to ever be fully resolved in a respondent's mind. This implies that an individual's valuation of any commodity or service is stochastic. It is best characterized as a random variable with an associated valuation distribution for treating "not sure" responses in the survey. In the WTA survey, a SPC approach was used in the choice questions to observe the producers' WTA to share their animal trait information, which allowed the estimation of individual valuation distributions.

The SPC approach is a special case of a multiple bounded discrete choice (MBDC) approach. The MBDC approach asks respondents certainty intensity questions over a range of price thresholds (Welsh and Bishop 1993; Welsh and Poe 1998), whereas numeric likelihood values are used in a SPC approach. Specifically, in a SPC approach, the respondent is presented with a table of prices in ascending or descending order and is asked about the likelihood that he/she would agree to pay each price. The use of a combination of words and numerical values allows respondents to better express themselves (Wang and Whittington 2005; Lloyd-Smith &

Adamowicz 2018). With SPC, the respondents can show the considerable value in their opinion and describe the statement better with the combination of words and numerical values. However, SPC approach might not be implemented correctly as it might be hard for identify the suitable variables for making the measurement. For making the SPC approach to be effective, the design of SPC variables should be made carefully. Table 4.1 shows an example of a standard SPC design. This question is part of the WTA survey. It is obvious that the SPC question used in the survey included 11 payment amounts from $0 to $10 per animal per year. Both worded responses and numerical terms are presented in the question. Therefore, when respondents see the question, they can more easily understand the decision they are being asked to make. For the researchers, this kind of design helps them to convert the likelihood of paying/accepting the prices into probabilistic terms in the dataset.

How likely would you be to collect and share the data in **group A** under this information sharing scenario if the third party were to offer compensation in the following amount (per head)? Please select a response for each payment amount (one response per row).

Compensation per Head of Animal	**Definitely no** (0% chance)	**Probably no** (25% chance)	**Not sure** (50% chance)	**Probably yes** (75% chance)	**Definitely yes** (100% chance)
$0	□	□	□	□	□
$1	□	□	□	□	□
$2	□	□	□	□	□
$3	□	□	□	□	□
$4	□	□	□	□	□
$5	□	□	□	□	□
$6	□	□	□	□	□
$7	□	□	□	□	□
$8	□	□	□	□	□
$9	□	□	□	□	□
$10	□	□	□	□	□

Figure 4.1 Example of a stochastic payment card design.

4.4. Econometric Approach

4.4.1. Binomial Logistic Regression Model

In a simple binomial logistic regression model, the choice variable is binary or dichotomous (Hosmer & Lemeshow, 2000). The binomial qualitative choice model (i.e., the logit model) is based on the cumulative logistic distribution and is specified as:

$$P_i = E(Y_i = 1|X_i) = {}^{1}/_{(1 + e^{-Zi})}$$

where $Z_i = \beta_1 + \beta_i X_i$, e is the base of natural logarithms, $Y_i = 1$ for choice = 1 (i.e., yes) and $Y_i = 0$ for choice = 0. P_i is the probability that an individual will make a certain choice when faced with two choices given X_i, which represents i individual characteristics (Brown, 1991). In the model, β_1 is the constant term and β_i is a vector of coefficients for X_i, and E means the expect value. Instead of estimating ordinary least square (OLS), the logistic regression uses the maximum likelihood estimation (MLE) to generate parameter estimates that give the greatest probability of obtaining the sample data. This is widely used in modelling choice behavior.

4.4.2. Random-effects Logit Model

Different from cross-sectional data analysis, panel data models can control for unobserved heterogeneity by considering it as having either a fixed or a random effect. It allows the econometrician to analyze repeated decisions/choices of each individual. In a random-effects logit model, unobservable factors are assumed to follow a discrete distribution. Random-effects logit model is a popular method to analyze multilevel data. However, the random-effects model is only valid if the unobserved heterogeneity is uncorrelated with the independent variable. In my study, the dependent variable is the individual-specific decisions. The independent regressors are a group of variables denoting the type of information sharing, personal variables that describe the primary decision makers of each farm, and operational characteristics. This model can suggest what kind of respondents are more likely to be involved in information sharing agreements instead of estimating a population average.

Lloyd-Smith and Adamowicz (2018) conducted a private goods experiment to examine the WTA to give up an hour of time at a later date in exchange for money. The authors used a SPC approach because it is well suited to the context by providing considerable value information for each respondent. They estimated a random-effects logit model to account for multiple responses per respondent for a SPC approach. In my study, I followed their general empirical approach. Same as the hour of time in Lloyd-Smith and Adamowicz's (2018) research, animal trait information in my study is considered as private good since money, time, and labor are being consumed when information is collected by cow-calf producers. I first estimated the model using only a constant term, the payment amount, the demographic variables of the primary farm decision-makers, and farm attributes. This is the baseline model:

$$Willingness\ to\ Share = f(P, A, G, E, An, RAn, Sim, F, Act, \mathcal{E}) \qquad (4.1)$$

Where "*Willingness to share*" is the decision made by each producer of whether to accept a specific payment amount to share information; "*P*" denotes the associated payment amount; "*A*", "*G*" and "*E*" denote variables for age category, gender, and education background, respectively (i.e., whether the primary decision maker graduated from an agriculture and genetics-related majors); "*An*", "*RAn*" and "*Sim*" are dummy variables that show whether an individual producer uses these breeds to breed calves; "*F*" denotes farm size; "*Act*" is whether a producer owns other type of operations; lastly, ε is the error term that captures all unobserved variables.

Next, I added the variable "P_C" to the base model to examine the effects of information collection rates on the producers' decisions. The adjusted model is as follows:

$$Willingness\ to\ Share = f(P, A, G, E, An, RAn, Sim, F, Act, P_C, \mathcal{E}) \qquad (4.2)$$

where "P_C" is the percentage of the number of collected animal trait information in each information set. This variable is significant because if cow-calf producers have already collected a specific animal trait information, it means that they require less costs, including both monetary costs and time inputs, to be able to share the information. Therefore, they may be more likely to be willing to share information.

According to the results of these models, I generated a specification which provides a better BIC. This is expressed in the following equation:

$$Willingness\ to\ Share = f(P, A, G, E, An, RAn, Act, P_C, \mathcal{E}) \qquad (4.3)$$

In order to examine the producers' willingness to share different types of information, dummy variables "*set2*" and "*set3*" are added. "*set1*" is omitted to avoid the dummy variable trap. This is expressed as:

$$Willingness\ to\ Share = f(P, A, G, E, An, RAn, Act, P_C, set2, set3, \mathcal{E}) \qquad (4.4)$$

Where "*set1*", "*set2*" and "*set3*" represent three different sets of information. "*Set1*" includes information on health/diseases and maternal traits, "*set2*" includes information on production/efficiency and parentage traits, and "*set3*" includes information on carcass traits.

In Lloyd-Smith and Adamowicz's (2018) paper, interaction terms between price amount and provision/price motivation were added in their random-effects logit models to examine the price sensitivity of different types of respondents. Following their approach, I also included interaction terms between producers' demographic variables/farm characteristic variables and the payment amount because these factors may have different impacts on the price sensitivity of respondents. It is shown in the following equation:

$$Willingness\ to\ Share = f(P, A, G, E, An, RAn, Act, P_C, Inter, \mathcal{E}) \qquad (4.5)$$

where "*Inter*" is a vector of different interaction terms between the payment amount and the producers' demographic variables/farm characteristic variables including "$P * A$", "$P * G$", "$P * E$", "$P * An$", "$P * RAn$", and "$P * Act$".

Table 4. 1 Definition of Variables

Variable	Definition
Choice (Dependent variable)	Binary variable where "1" indicates that the respondent is willing to share animal trait information
Price Amount	Variable indicating the payment amount offered to the respondents
Age	Categorical variable indicating the age range of the primary decision maker of each cow-calf farm
Gender	Binary variable where "1" indicates that the primary decision maker of the farm is male
Agriculture-related Majors	Binary variable where "1" indicates that the primary decision maker of the farm studied in agriculture or genetics related majors
More Activities	Binary variable where "1" indicates that the farm conducts other activities including backgrounding and finishing animals
Angus	Binary variable where "1" indicates that the farm uses Angus animals for breeding
Red Angus	Binary variable where "1" indicates that the farm uses Red Angus animals for breeding
Simmental	Binary variable where "1" indicates that the farm uses Simmental animals for breeding
Farm Size	Categorical variable indicating the range of the animal number in each farm
Percentage of Collected Information	Variable that indicating the percentage of the number of collected animal trait information in each information set
Set1	Binary variable where "1" indicates Set One information including Health/Diseases and Maternal Traits
Set2	Binary variable where "1" indicates Set Two information including Production/Efficiency and Parentage Traits
Set3	Binary variable where "1" indicates Set Three information including Carcass Traits
Interaction Terms	A vector of different interaction terms between price amount and other characteristics of producers and farms including amount*age, amount*gender, amount*education, amount*angus, amount*redangus, and amount*moreactivities

In this section, a summary of variables is described in Table 4.1. Choices of information sharing by respondents is the dependent variable in the regression model to evaluate animal trait information sharing preferences of commercial cow-calf producers. According to assumptions and data analysis in chapter 3, potential compensation amount from BAs, demographic variables of producers, farm characteristics were used to estimate the dependent variable. The percentage of the number of collected animal trait information in each information set is then added to the model. This is an important variable for observing how the extent of information collection influences the producers' willingness to share information. It is assumed that if the producers are required to share data that they do not have, the potential cost of collecting data might prevent them from information sharing, even though economic compensation will be provided. Different sets of information and some interaction terms were added to observe the influence of information type on the producers' choices.

4.5. Conclusion

In this chapter, I described the methods that I used to assess the WTA of commercial cow-calf producers for sharing their animal trait information and the reasons behind why these approaches are used. WTP is relatively more commonly used in evaluating preferences. However, there is evidence showing that under certain situations, the WTA approach can generate the same results. The SPC approach uses a combination of words and numerical values to better express preferences. The use of the SPC approach helps to convert the likelihood of paying/accepting the prices into probabilistic terms. Lastly, I described the specific econometric approach that I use: a random-effects logit model, which allows me to analyze repeated decisions/choices of each producer.

Chapter 5. Results

5.1. Introduction

This chapter presents the results generated from the willingness-to-accept (WTA) analysis in a sequence of steps. Firstly, descriptive results from the survey will be presented. Next, data from the WTA survey is analyzed using random-effects logit models, and the econometric results will be presented and discussed.

5.2. Descriptive Results

Table 5.1 provides a summary of the types of participants and the WTA values for each type of producer on sharing different groups of information. According to Table 5.1, Angus producers are more likely to be willing to share information, and their average WTA is lower than the WTA of the entire sample. The t-test shown in Table 5.2 shows that this difference is statistically significant. However, the t-test result does not show how gender influences the mean WTA. In addition, I assumed that producers who own a farm with both cow-calf and backgrounding/finishing activities expect lower cash compensation to share production traits (group B) and carcass traits (group C) than the mean WTA of the entire sample because they can obtain production and carcass information easier than the other producers. However, the data does not support the assumption. The t-test implies that there is no statistically significant difference between this group of producers and the overall sample average. It may be potentially influenced by the unknown cost of collecting information. In information group A, most of the traits are already recorded by most producers. Not many producers collect production and carcass traits if these traits do not significantly influence their farm profits. Therefore, the costs of collecting this information are unknown to most of the producers. The mean WTA to share information in both group A and B (group A+B) and in all three information groups (group

A+B+C) do not vary a lot. Producers who have university degrees with agricultural or genetics-related majors do not show a pronounced difference from the overall sample in terms of WTA, and this is supported by the t-test result. This is also contrary to my expectation because I hypothesized that this type of producer would better understand the value of genetic information and its importance for the beef industry. However, the data may not show this difference since all of these producers, regardless of educational background, are working in the beef industry. It is not necessarily true that the study background influences the producers' knowledge of the industry especially for those who have been away from school for many years. It is also possible that my assumption is not necessarily correct because some well-educated producers may have their own perspectives on genetic information sharing. Specific economic risks may be incurred by commercial cow-calf beef producers resulting in a reluctance to share their animal trait information with BAs, or other supply chain actors like feedlots or packing plants. Literally, producers with more understanding of the industry can better cognize the potential risks behind information sharing. They may be afraid of sharing information since they fear that their data may be used against them. For this reason, producers with better understanding of genetic information may be less likely to share their information.

Table 5. 1 WTA to Share Animal Traits Information in Each Information Group

	Group A		Group A+B		Group A+B+C	
	N	Mean WTA	N	Mean WTA	N	Mean WTA
Overall	46	\$4.96	39	\$5.87	34	\$6.65
Angus	33	\$4.67	28	\$5.36	25	\$6.32
Gender	37	\$5.19	32	\$5.69	29	\$6.66
More Activities	29	\$4.66	26	\$5.88	25	\$6.56
Agriculture-related Majors	23	\$4.87	18	\$5.89	16	\$6.56

Table 5. 2 T-test of Mean WTA to Share Animal Traits Information in Each Information Group

Variables	Mean	Std. Err.	$Pr\ (\lvert T\rvert > \lvert t\rvert)$
Overall	5.8267	.4883	.0308
Angus	5.4500	.4784	
Overall	5.8267	.4883	.8815
Gender	5.8467	.4315	
Overall	5.8267	.4883	.2999
More Activities	5.7000	.5558	
Overall	5.8267	.4883	.2830
Agriculture-related Majors	5.7733	.4913	

5.3. Random-effects Logit Model Results

The polychotomous responses for each payment level were converted into a binary variable using “Probably Yes (75%)” as the lower bound cut-off for a “yes” response and coded as “1”. These converted binary responses are used to estimate random-effects logit models to account for multiple responses per individual. There are 52 participants in total, 11 payment amounts, and three scenarios with different groups of animal traits. This means that each respondent was made 11 choices for three time. Therefore, after calculating 52 times 11 and times 3, we can get a total of 1,716 observations.

Model I, which was described in the baseline model (equation 4.1), involves a constant term, the payment amount, and demographic variables such as age, gender, and education background (whether the primary decision maker graduated from an agriculture and genetics-related major or not) of the primary farm-level decision-makers. The result is shown in the first column of Table 5.3. As expected, the higher the payment, the more likely a respondent is willing to share information. However, among the demographic variables of primary decision-makers, no variable is statistically significant, which suggests that the characteristics of the primary decision-makers do not impact the producers' choices on information sharing. This result is different from my expectation that was described in chapter 3. In that section, I concluded that age, gender, and education can be the factors affecting the producers' choices on sharing information. In addition, different types of producers have different points of view towards a new project or technology. For producers who are not currently sharing information, this is a different information sharing scenario. Old and young producers, male and female producers, and producers in different study areas can have different decisions on information sharing. However, the models do not show this. Among the variables for farm attributes, operations which use Angus and/or Red Angus animals in breeding are more likely to be willing to share information, given the positive and significant coefficients of "angus" and "red angus" variables. Operation farm size, integration level of farms and whether a farm uses Simmental animals in breeding are not statistically significant. Farm size, as discussed in chapter 3, was considered as an interesting variable. Large farms can have advantages in information collection due to their economies of scale. Thus, they may be more likely to be willing to share their animal trait information due to their lower costs of collecting data. They can also be less likely to say "yes" to share their information due to reasons related to their management strategies (e.g., they may want to keep their information secret in order to be more competitive in the market). Therefore, the coefficient of this variable can be either positive or negative sign. Because of this, it is not a surprise that I got a statistically insignificant result for this variable.

Then, following equation 4.2, I included the percentage of the number of collected animal trait information in each information set referring to Model II. The results of this model are presented in the second column of Table 5.3. In agreement with my expectation, the positive and significant coefficient implies that as the amount of collected information increases, the likelihood of the producer willing to share this specific group of information also increases. This makes sense because one of the most important factors affecting farm-level decisions is the cost of the animal information collection. For s traits information that has already been collected, there is no new additional time or monetary cost, so it is sensible that producers are more willing to share collected data than non-collected data. This variable is important because it reflects whether the cost of collecting information influences the producers' willingness to share data.

Table 5. 3 Random-Effects Logit Models of the Farm Level Information Sharing Decisions

Variable	Model I	Model II
Constant	-9.66***	-13.17***
	(2.61)	(2.87)
Price Amount	0.64***	0.67***
	(0.04)	(0.04)
Age	0.35	0.56
	(0.38)	(0.41)
Gender	-0.03	0.44
	(1.50)	(1.60)
Agriculture-related Majors	0.46	-0.18
	(1.16)	(1.24)
Angus	2.08*	2.60*
	(1.27)	(1.35)
Red Angus	2.17*	2.70**
	(1.25)	(1.34)
Simmental	1.43	1.30
	(1.26)	(1.35)
Farm Size	-0.0002	-0.0002
	(0.0005)	(0.0005)
More Activities	-0.26	-1.22
	(1.17)	(1.27)
Percentage of Collected Information		6.67***
		(1.16)
LR test of $\rho = 0$ (prob>=$chibar^2$)	0.00	0.00
Log Likelihood	-542.97	-524.70
BIC	1167.86	1138.78

Note: Standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01. There are 52 participants in each model with a total of 1,716 observations.

The value of 0.00 for the likelihood ratio (LR) test of $\rho = 0$ indicates that the random-effects logit model can better explain the dataset than a simple logit model. This result can be considered to be expected. According to the discussion in chapter 3 and chapter 4, the same producer might have different attitudes towards the sharing of different types of information. The elements they consider might not be the same for different types of information. Furthermore, the elements that are related to the information sharing behavior are not always the same. The elements listed in the survey might have random effects on information sharing behavior. Therefore, based on this reason, the simple logit model might not be suitable for explaining the result. Moreover, as discussed in chapter 4, panel data models can control for unobserved heterogeneity. It allows me to analyze repeated decisions/choices of each individual. Therefore, the random-effect logit model can be more suitable. As more variables are added, the log likelihood decreases slightly, but in the first three specifications, the magnitude of the Bayesian Information Criterion (BIC) increases as more variables are added. The BIC is a type of model selection method among a class of parametric models with different numbers of parameters. The increase of BIC when more variables are added may be caused by an overfitting issue. Therefore, I used fewer explanatory variables in model III as shown in the first column of Table 5.4. Model III, according to equation 4.3, presents a better specification comparing to Model II based on their BIC values.

Table 5. 4 Random-Effects Logit Models of the Farm Level Information Sharing Decisions with "Information Set" Dummy Variables and Interaction Terms

Variable	Model III	Model IV	Model V
Constant	-12.22***	-8.87***	-10.70***
	(2.70)	(3.32)	(3.00)
Price Amount	0.67***	0.82***	0.29*
	(0.04)	(0.05)	(0.15)
Percentage of Collected Information	6.71***	-1.17	7.01***
	(1.16)	(1.55)	(1.19)
Set2		-1.84***	
		(0.25)	
Set3		-3.42***	
		(0.34)	
Amount*age			-0.06*
			(0.03)
Amount*gender			0.40***
			(0.10)
Amount*agmajor			0.0027
			(0.09)
Amount*angus			0.11
			(0.10)
Amount*redangus			0.27***
			(0.09)
Amount*moreactivities			0.24***
			(0.09)
LR test of $\rho = 0$ (prob>=$chibar^2$)	0.00	0.00	0.00
Log Likelihood	-525.14	-451.66	-505.77
BIC	1124.76	992.69	1130.69

Note: Standard errors are presented in parentheses. *p<0.1, **p<0.05, ***p<0.01. There are 52 participants in each model with 1,716 observations. Producer demographic variables including "age", "gender" and "agriculture-related majors" and farm characteristic variables including "angus", "red angus" and "more activities" are estimated in all the models in this table but not presented.

In order to look at the producers' willingness to share different sets of information, dummy variables "set2" and "set3" are added. Here, the excluded information set 1 is Group A information, which includes health/disease and maternal traits information. Set 2 includes both Group A and Group B (production/efficiency and parentage information) information, and set 3 is Groups A, B and C (carcass traits information). This model is shown in the second column of Table 5.4 referring to Model IV, which is estimated as described in equation 4.4. These two variables both have negative and significant coefficients, meaning that producers are more likely to share information in set 1 than set 2 and 3. Since my survey targets cow-calf producers, maternal traits and health/disease of their animals are more related to their daily management than the other two groups of information. Therefore, it is easier for them to record information in Group A than the other two groups of data. In addition, information set 2 and set 3 require producers to share more data, so it is not hard to explain why they are more willing to share set 1 information under the same cash compensation amount. However, the variable "Percentage of Collected Information" is not significant after adding the dummy variables "set2" and "set3". Variable "Percentage of Collected Information" is the percentage of the number of collected animal traits in each information set, so this factor remains the same in each information set for each participant. It explains the variation that "set2" and "set3" explained in Model IV.

To explore the relationships between the explanatory variables and the decision to share information in more detail, my next step is to incorporate interaction terms between the producers' demographic variables/farm characteristic variables and the payment amount (Model V), which is described by equation 4.5. These interaction terms may have different impacts on the price sensitivity of respondents. Given the negative significant coefficient for "amount*age", it can be concluded that younger producers indicated more price sensitivity than older producers.

Furthermore, the interaction term between gender and payment amount is positive and statistically significant as male producers are more price sensitive. This means that the willingness to sharing information of male producers may change when cash compensation increases. Moreover, female producers are less likely to change their minds on information sharing even higher cash compensation is offered comparing to male producers. Same as gender, the positive and statistically significant coefficient for "amount*redangus" implies that producers using Red Angus animals for breeding are more price sensitive than other producers. However, the coefficient for "amount*angus" is statistically insignificant. A potential explanation for this difference is that BAs value distinct animal traits and use different methods to predict EPDs, so their producer base maybe quite heterogonous. However, this is just an assumption because the WTA survey in this study did not include enough variety of BAs. In addition, the positive and significant coefficient "amount*moreactivities" imply that cow-calf producers who also own backgrounding and/or finishing operations are more price sensitive. According to these implications, breeding associations (BAs) who need commercial data for more accurate genomic predictions can use different price strategies towards different groups of producers in order to collect information of cow-calf operations. Based on the analysis made in Chapter 3, some producers with certain features, such as age, gender and educational background might have the similar attitudes toward information sharing.

In general, the attitudes of these producers regarding information sharing are positive. Furthermore, with certain compensation, producers are more willing to share information. However, as the result shows, there are varying degrees of difficulty in terms of collecting the data for information sharing. The degree of difficulty in collecting data can influence the attitudes of producers toward compensation and information sharing behavior. For different farm size and systems of operation, producers might also have different degrees of tolerance for the difficulty of information collection. In this scenario, the price sensitiveness of producers might not be the same. This would then lead to strategy adjustments from BAs for collecting different groups of information among the producers. To attract more producers for effective information collection, BAs should consider the price thresholds for different kinds of producers and different groups of information collection.

BAs should be aware that not every producer can accept the term of collecting information at the same price. Therefore, it might not be effective to have one unified strategy for collecting information from different producers. Instead, BAs should take into consideration the unique features of producers when proposing certain terms for sharing information. In this way, the strategy and the terms of compensation can be tailored accordingly for different groups of information sharing. With different terms, BAs can attract as many producers as possible based on the terms that they can accept.

In addition, I used different methods of coding the dependent variable to conduct a robustness check. The lower-bound threshold level for "yes" response is "probably yes (75%)" in all the models estimated in the previous tables. Alternatively, "Definitely yes (100% chance)" is used to estimate all the specifications as well. The results from this alternative lower bound cut-off are consistent with the qualitative patterns from table 5.3 and table 5.4.

5.4. Discussion of Results

This study examined the WTA of cow-calf producers for sharing genomic information on different groups of animal traits using data from a survey of cow-calf producers in Alberta. Random-effects logit models with different specifications are estimated and the econometric results are presented in this chapter.

Firstly, according to the summary of the average monetary WTA of different types of producers to share animal trait information in different information groups, a higher cash compensation is expected by producers when they are required to share more data. In addition, different types of producers can have different WTA to share the same amount of information (i.e., cow-calf producers who use Angus animals for crossbreeding have lower WTA than the overall sample on average). Therefore, for BAs who need more genomic information to predict EPDs more accurately for better genetic selection, they can choose specific types of targets/cow-calf producers to gain commercial data. Secondly, the econometric results of Model I show that when higher cash compensation is offered, a producer is more likely to be willing to share genomic information. Demographic variables of producers have little impact on their decisions according to the results of Model II, but age and gender can influence the elasticity of cash compensation of sharing data. Some characteristics of farms (e.g., whether a producer uses Angus or Red Angus animals for breeding) have an impact on the producers' decisions on information sharing, and some factors (e.g., whether a producer owns backgrounding/finishing operations) also have influence on the elasticity of cash compensation. Thirdly, by estimating the percentage of the number of collected animal trait information in each information set in Model III, I concluded that producers are more willing to share collected information rather than non-collected information under the same cash compensation amount since sharing collected data requires less costs. To summarize, BAs can gain commercial data from specific types of cow-calf producers in order to increase the accuracy of EPDs if they can offer enough cash compensation.

The main points of this study have given BAs a direction to establish certain strategies to promote information sharing. BAs can apply price discrimination towards different types of producers. As discussed above, producers can be categorized into different groups based on their age, gender, education background, farm size and farm operation. Economic incentives, like cash compensation, can be used to attract young and male producers to join in information sharing. Moreover, in the information sharing process, producers need to collect animal trait information. For some producers, they might already have the system or process in place for collecting this kind of data. With this system already in place, they might not need to spend extra time or money for data collection. Thus, their tolerance and the WTA the information sharing behavior might not be the same compared to the producers who do not have such a system. These different categories have an influence on their willingness to accept the information sharing proposal. In addition, their attitudes and demographic features might decide whether they will share the information and the amount of compensation they would expect for sharing this information. Moreover, the system in the farm, the size of the farm, and the breed of the cattle might relate to the behavior of producers for information sharing. These elements could also have certain internal relationships with each other. For example, the farm size and farm operation system might decide the behavior of the data collection process. It can then lead to the economic considerations of the producers. Moreover, their age, gender and education background might influence the producers' attitudes and their perceptions about information sharing. These perceptions about potential personal benefits from information sharing might also impact their compensation expectations. In this circumstance, their bargaining position for compensation might not be the same, and their willingness for sharing the information might also be impacted.

When BAs understand the differences among producers, they can establish suitable strategies for persuading producers to accept information sharing. Offering compensation is one of these strategies. However, if the producers cannot realize the potential economic benefits in further genomic selection, they might focus solely on monetary compensation. Because of this, BAs should also pay attention to the promotion of potential benefits of information sharing, such as the benefits in genomic selection that can lead to greater economic value in breeding. In this way, if producers can better understand the benefits of information sharing behavior, then they are more likely to be willing to collect and share data. For increasing the willingness of producers to collect data, BAs should consider the farm size and their operational system when they invite the producers into certain information sharing projects. In other words, BAs should not focus on providing compensation to producers to encourage the producers to share information. Instead, BAs should create strategies and plans that tailor to different producers and focus on communicating the importance and benefits of information sharing. In this way, it can be expected that producers might have new perceptions about information sharing and become more prone to accept the invitation.

Chapter 6. Conclusion

6.1. Summary of the Thesis

Chapter 6 concludes the thesis by summarizing, and briefly discussing the main implications of the results. Limitations of this study and a discussion of future research are presented in this chapter as well.

Breeding associations (BAs) play an important role in predicting and improving animal genetics in the Canadian beef cattle industry. Achieving this through genomic selection, however, requires a large amount of genotypic and phenotypic data. Even though purebred producers are required to share their animal trait information with BAs, the data from the animals whose parents are sold to commercial producers as breeding cattle are not reported to BAs. The purpose of this study is to investigate the feasibility of setting up incentive schemes to help collect genomic information from commercial cow-calf producers. Specifically, I investigate how animal phenotypic data collected by commercial cow-calf beef cattle producers can be shared with BAs. The research is focused on estimating the amount of money it would take to incentivize commercial cow-calf producers to share animal-trait related information, or their WTA. A WTA survey was conducted in the Alberta area between October 2019 and January 2020, where 52 cow-calf producers completed the survey. Results from a random-effects logit model suggests that cash compensation is a potential motivation for producers to share their phenotypic animal data. When producers are involved in information sharing, higher cash compensation is expected when more data sharing is required. Producers can also have different WTA to share same amount of information. Demographic variables of producers have little impact on their decisions, but age and gender can influence the elasticity of cash compensation of sharing data. Some characteristics of farms (e.g., whether a producer uses Angus or Red

Angus animals for breeding) can impact their decisions on information sharing, and some factors (e.g., whether a producer owns backgrounding/finishing operations) can also influence the elasticity of cash compensation. Producers are more willing to share collected information rather than non-collected information under the same cash compensation since sharing collected data requires less costs.

6.2. Implications

This study contributes to the current literature by conducting an analysis of the WTA by commercial cow-calf producers to share their animal trait information with cattle BAs. One novel contribution of this study is the consideration of the phenotypic information collected from the producers as private goods. In addition, we proposed to investigate the feasibility of setting up economic incentive schemes to help BAs collect phenotypic information from commercial cow-calf producers. Moreover, the results from this study have shown various elements that can influence the attitudes of the producers toward information sharing. This allows BAs to build relationships with commercial producers. Last but not least, the implications from this study are applicable toward BAs, producers, and policy decisions makers.

Firstly, the implications from this study for BAs include the need to enlarge their commercial phenotypic data set by selecting producers based on their attributes. For instance, according to the results, younger producers and male producers are more willing to share their information, and producers with agriculture and genetics degrees express greater interest in sharing their information. Therefore, BAs could collect animal-trait information from these groups of producers with lower cost. In addition, it could be easier for BAs to collect information from producers who have already collected this information for their own use because the results show that producers are more willing to share their information if no extra collection effort is needed. According to the results of Model V, BAs can use different price strategies for different groups of producers to collect animal-trait information from cow-calf operations. For instance, younger producers indicate higher price sensitivity than older producers. Therefore, BAs could price discriminate and provide younger producers with less money to obtain their information. However, cash compensation is not the only way for BAs to attract producers to share information. According to the analysis in chapter 3, economic incentives are not the only potential helpful tool to implement information sharing. 61% of the respondents in the WTA survey have shared their information without any monetary compensation. Except for cash compensation, there are other incentive tools induce producers to share their information. For instance, BAs can motivate producers with lower price sensitivity by providing certain farm-level services (i.e., offering them genetic prediction with discounts), or by offering certification to help their operations sell the animals for a premium.

Secondly, for producers, they can benefit from genetic information sharing by being able to purchase breeding animals with more accurate EPDs, leading to reduced production risk and potentially greater profits. In the long term, the entire industry could begin to see its overall quality increase, which benefits producers as well.

Lastly, for policy decision makers, cash compensation is a useful tool to make information sharing feasible. The payment amount can impact the producers' willingness to share their information. This scheme can also be implemented in other part along the beef supply chain and can be applied in other industries inside and outside of the agricultural sector. However, there are many elements that can potentially affect the payment amount. For instance, a feasible cash compensation of information sharing highly depends on the difficulty of collecting data. Different types of producers may spend different time and money on data collecting (per animal). Therefore, decision makers can use price discrimination tool to determine the payment amount in information sharing.

6.3. Limitations & Future Research

There are several limitations in this research, some of which have been acknowledged in the chapter 4 and chapter 5. The most critical limitation is that the total number of participants who replied to the survey was quite low, at only 52. The sample was skewed in that it had a higher proportion of younger producers and female producers than the overall population. The small sample size and the imbalanced age and gender ratios can introduce limitations and biases in the results of this study. Secondly, only 11 payment amounts from $0 to $10 were included in the WTA questions. Moreover, I found several respondents answered "no" in all the payment cards. For this group of respondents, it is difficult to observe their WTA because their true WTA might be an infinite amount (i.e., they are not willing to share information at all), or it might be because they were not serious when they took the survey. In addition, this research only studied on the economic incentive of producers to share information. In the result chapter, it concludes that BAs can use less cash to obtain genetic information from certain types of producers with high price sensitivity. However, there may exist some issues to gather information from a cheap way. For example, these groups of producers may provide data with low quality (i.e., not accurate).

These limitations would make the research result to show the common attitude of a certain group of people. They have the similar demographic background. However, this kind of results might have the bias which would not be good for the association to design the suitable WTA for encouraging more producers into the information sharing system. The respondents who are willing to take the questionnaire might be more open to the information sharing. But the larger group of producers might not have this kind of opinion. Therefore, the demand of these producers cannot be shown in the result of this research. In this circumstance, the limitation of this research has impact on the generalization of the research result.

There are at least four future extensions related to this study. Firstly, I recommend the collection of new WTA data with a larger sample size, wider payment range, more representative age and gender ratios, and possible additional attributes. These modifications could give more precise and less biased results because a larger sample size would decrease the variability and adding a relevant variable could prevent bias in the estimation of other regression coefficients. Secondly, this study only looked at the WTA for commercial cow-calf producers to share their information, but one could also investigate the WTP by BAs to receive the data. Comparing these two aspects is meaningful for the transmission of genomic information. For instance, if the WTP for BAs to receive commercial animal-trait information is lower than the WTA for producers to share the information, the incentive scheme of information transmission would not work. Thirdly, three WTA questions asked the WTA of increasing numbers of animal traits, as shown in Question B2 in the survey in Appendix 1. If given another opportunity to conduct the survey, I would add more questions to find the WTA of sharing different types of information, which is a potential factor that may affect the producers' decision-making regarding information sharing. Lastly, I also recommend designing information sharing scenarios with distinct attributes and to use choice experiments to calculate the non-market values of commercial information using WTA or WTP approaches. This could provide more straightforward suggestions about genetic information transmission for decision makers.

In conclusion, the feasibility of commercial genetic information transmission is meaningful to the Alberta beef industry by stabilizing the output and generating larger profit in the long term. By building effective information sharing systems between BAs and commercial cow-calf producers, genetic dataset is enlarged. More accurate EPDs can be estimated, which benefits both BAs and producers. Animal performance might be more consistent, which means producers have less risk in production activities. If this scheme can be utilized along the entire beef cattle supply chain, the industry could become more competitive than before.

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Appendix

Appendix 1. Survey for commercial cow-calf producers

SCREENER QUESTION:

Before starting to take the survey, please answer this question.

Are you a commercial cow-calf producer in Alberta who is 18 years of age or older?

□ Yes

□ No

CONTINUE IF “Yes”, ALL OTHERS THANKS & TERMINATE

Ethics: Information and Consent

Study Title:

The Economics of Genomic Information Sharing in the Alberta Beef Sector.

Dear beef producer,

You are invited to participate in this internet-based research survey in which we investigate how producers feel about the use of genomic information. This study will be conducted in Alberta and is carried out by graduate student Ms. Freya Feng under the guidance of her graduate advisors Dr. Philippe Marcoul and Dr. Henry An in the Department of Resource Economics and Environmental Sociology (REES) at the University of Alberta. Our research partner is Ms. Dawn Trautman who is a Program Manager of Smart Agriculture and Food Innovation at Alberta Innovates. This study is funded by the Alberta Ministry of Agriculture and Forestry.

This study will analyze the economic incentives that commercial cow-calf producers have to collect their animal trait information and share it with breeding associations. More specifically, the research will attempt to determine the willingness of commercial cow-calf producers to accept a compensation to share their information and the willingness of breeding associations to pay to obtain this information.

Information

Purpose: The purpose of this study is to investigate how the sharing of genomic information can benefit the Alberta beef sector.

Methods: You will be asked to give us your opinions via a questionnaire. We expect that it will take you approximately 20 minutes to complete. Please make use of the text box at the end of the survey to share any thoughts and/or questions with us.

Confidentiality: Your participation is voluntary. All of your answers will be kept strictly confidential and grouped with responses from other participants and will not be identifiable or attributable to you. You are invited to submit your email address to receive a summary report once this study is completed, but this is voluntary. Your email address will be used to send you a summary report only, and no sales solicitation is involved. Please note that your name or any other identifiable information will not be associated with survey responses. The data from this survey will be stored in a password-protected folder for a minimum of 5 years following the completion of this research project, and will only be accessible by Ms. Feng, Dr. Marcoul, Dr. An and Ms. Trautman for research purposes.

Benefits: As part of Alberta's beef industry, we value your input and we also believe that you may personally benefit from the results of this study as one objective of this study is to identify pathways to improve the overall productivity of the beef sector. There are no costs to be incurred by you if you choose to be a participant of this research project, and there are no reasonably foreseeable risks that may arise out of your participation in this survey.

Prize Draw: We are going to provide a $100 dollar restaurant gift card as part of a prize draw. To be eligible for the prize draw, you must answer every question on the survey. In addition, you will be required to provide your email address or phone number so that we may contact you. Your contact information will not be used in any data analysis or linked to any answers, and all the information will be saved in a password protected file. Once we have closed our survey, the prize will be drawn, and the winner will be contacted. Please note that you are not obligated to enter the draw if you choose not to, as this is completely voluntary.

Withdrawal: You may withdraw from the study at any point in time, however responses already submitted cannot be withdrawn.

Please take as much time as you need to answer all the questions. This survey and research project have been approved by the Research Ethics Board (REB) at the University of Alberta (REB Project ID: Pro00090439). For questions regarding participant rights and the ethical conduct of research, please contact the Research Ethics Office at 780-492-0459.

Consent

We will ask for your consent to participate in this study on the next page. You are welcome to contact any of the project collaborators (contact details below) to discuss any aspect of this study further.

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I have read the Information Sheet dated _____________, and the research study authored by Ms. Feng entitled "The Economics of Genomic Information Sharing in the Alberta Beef Sector" has been explained to me. I understand that I have been asked to be in a research study, and I understand the benefits and risks involved. If I have any questions, I have been told whom to contact. I agree to participate in the research study described before.

By checking the box "Yes", I am indicating that I have read and understood the above information and give consent to participate in this study.

□ Yes □ No

In order to help you complete this survey, the concept of *genetic selection* (GS) and expected progeny differences (EPDs) will be introduced:

Genetic Selection (GS) is traditional selective breeding, where breeders use both observed traits and genetic information to specifically develop and propagate traits of interest in the offspring. Through these practices, promising breeding stock is identified and prioritized for breeding. Genomics allows producers to select and breed livestock based on specific DNA information. This technology makes the selection process faster and more accurate (e.g., an unborn individual may be selected based on DNA-validated traits of the parents before birth).

Expected Progeny Differences (EPDs) provide estimates of the genetic worth of an animal as a parent. EPDs are based on animal models which aggregate all information known about an individual and its relatives to build a genetic profile of its merits. These profiles are then compared to other individuals used for the breeding decision making of producers. However, these estimates are only compared to the individuals of the same breed.

Section A. General Information.

In this section, we are interested in ***information related to your operation***.

A1. Are you, the person who is completing the survey, the primary decision-maker for the operation?

□ Yes □ No

A2. Please specify your role.

□ Owner / co-owner

□ General manager

□ Spousal partner

□ Other _________

A3. Who else is actively involved in general decision-making for this operation? Please check all that apply.

□ Spouse

□ Other family members

□ Non-family partners

□ Accountant/Consultant

□ No one else

□ Other, please specify: ______________________

A4. How old is the primary decision-maker on your operation?

□ 25 or under

□ 26 to 35

□ 36 to 45

□ 46 to 55

□ 56 to 65

□ Above 65

A5. What is the gender of the primary decision-maker on your operation?

□ Female

□ Male

□ Other

□ I do not know

A6. What is the highest level of education obtained by the primary decision-maker on your operation?

□ Elementary school or junior high school

□ High school

□ Diploma/certificate in agriculture or genetics related major

□ Diploma/certificate in other subject

□ Bachelor's degree in agriculture or genetics related major

□ Bachelor's degree in other subject

□ Master's or doctoral degree in agriculture or genetics related major

□ Master's or doctoral degree in other subject

A7. Besides your cow-calf operation, what other types of activities are conducted on your farm?

□ None

□ Backgrounding

□ Feedlot/finishing

□ Slaughterhouse

□ Packing

□ Other, please specify: ____________

A8. In the past 5 years, how many mother cows have you had on your operation each year on average?

____

A9. In the past 5 years, how many bulls did your operation use for breeding purposes each year on average?

____

A10. In the past 5 years, how many bulls did your operation replace each year on average?

____

A11. In the past 5 years, how many replacement bulls did your operation buy each year on average?

____

Now that we have some idea about the structure of your operation, we'd like to ask you some questions about ***animal trait data and data collection***.

A12. EPDs can be an important tool for animal selection, how important are the following animal traits for you when thinking about which animals (cows and bulls) to select (or not select) for breeding purposes?

Animal Traits	**Unimportant**	**Of little importance**	**Moderately important**	**Important**	**Very important**

Calving Ease	□	□	□	□	□
Birth Weight	□	□	□	□	□
Weaning Weight	□	□	□	□	□
Yearling Weight	□	□	□	□	□
Scrotal Circumference	□	□	□	□	□
Gestation Length	□	□	□	□	□
Productive longevity of cows	□	□	□	□	□
Carcass Weight	□	□	□	□	□
Marbling Score/% Intramuscular Fat	□	□	□	□	□
Rib Eye Area	□	□	□	□	□
Fat Thickness between 12^{th} and 13^{th} rib	□	□	□	□	□
Meat Tenderness	□	□	□	□	□
Horned or Polled	□	□	□	□	□
Pigmentation & Coat Color	□	□	□	□	□
Double Muscling	□	□	□	□	□
Feed Efficiency/Dry Matter Intake	□	□	□	□	□
Calf Health/Calf Survivability	□	□	□	□	□
Docility	□	□	□	□	□
Any Congenital diseases	□	□	□	□	□
Any Other Diseases and Health Treatment	□	□	□	□	□

Parentage Information	□	□	□	□	□

A13. How difficult is it for you to collect information on the following animal traits? Please also check the first column if you are already collecting some of the traits.

Animal Traits	**I am already collectin g this data**	**Not at all difficult**	**Slightly difficult**	**Modera tely difficult**	**Difficult**	**Extreme ly difficult**
Calving Ease	□	□	□	□	□	□
Birth Weight	□	□	□	□	□	□
Weaning Weight	□	□	□	□	□	□
Yearling Weight	□	□	□	□	□	□
Scrotal Circumference	□	□	□	□	□	□
Gestation Length	□	□	□	□	□	□
Productive longevity of cows	□	□	□	□	□	□
Carcass Weight	□	□	□	□	□	□
Marbling Score/% Intramuscular Fat	□	□	□	□	□	□
Rib Eye Area	□	□	□	□	□	□
Fat Thickness between 12^{th} and 13^{th} rib	□	□	□	□	□	□
Meat Tenderness	□	□	□	□	□	□
Horned or Polled	□	□	□	□	□	□
Pigmentation & Coat Color	□	□	□	□	□	□
Double Muscling	□	□	□	□	□	□
Feed Efficiency/Dry Matter Intake	□	□	□	□	□	□

Calf Health/Calf Survivability	□	□	□	□	□	□
Docility	□	□	□	□	□	□
Any Congenital diseases	□	□	□	□	□	□
Any Other Diseases and Health Treatment	□	□	□	□	□	□
Parentage Information	□	□	□	□	□	□

A14. Which cattle breeds do you use for crossbreeding? Please check all that apply **AND** also indicate the percentage of each breed that you use. Please note that your figures should add up to 100%.

□ Angus ______________

□ Red Angus ______________

□ Simmental ______________

□ Charolais ______________

□ Hereford ______________

□ Limousin ______________

□ Gelbvieh ______________

□ Shorthorn ______________

□ Speckle Park ______________

□ Maine Anjou ______________

□ Salers ______________

□ Galloway ______________

□ Blonde D' Aquitaine ______________

□ Highland ______________

□ Dexter ______________

□ Lowline ______________

□ Hays Converter ______________

□ Luing ______________

□ Braunvieh ______________

□ Red Poll ______________

□ South Devon ______________

□ Tarentaise ______________

□ Welsh Black ____________

□ Others, please specify: ____________ ____________

We are now going to move to some questions about ***your willingness to share your animal information***.

A15. Are you currently sharing/transmitting or did you share/transmit any data listed in *Question A13* with other beef cattle producers, breeding associations, processors, retailers, researchers or any other institutions/companies (i.e., TrustBIX) ?

□ Yes *Please proceed to Question A16*

□ No *Please proceed to Question A19*

A16. Which animal-trait related information do you share with others (e.g., beef cattle producers, breeding associations, etc.)? Please check all that apply.

Animal Trait Information	**Shared (√)**	**Animal Trait Information**	**Shared (√)**
Calving Ease		Meat Tenderness	
Birth Weight		Horned or Polled	
Weaning Weight		Pigmentation & Coat Color	
Yearling Weight		Double Muscling	
Scrotal Circumference		Feed Efficiency/Dry Matter Intake	
Gestation Length		Calf Health/Calf Survivability	
Productive longevity of cows		Docility	
Carcass Weight		Any Congenital diseases	
Marbling Score/% Intramuscular Fat		Any Other Diseases and Health Treatment	
Rib Eye Area		Parentage Information	
Fat Thickness between 12th and 13th rib			

A17. Currently, what benefits do you receive from sharing animal-trait related information? Please check all that apply.

□ I receive cash compensation.

□ I can obtain certification that may help my operation to sell the beef/calves with a premium.

□ I receive some discounts for services (e.g., EPDs estimation) that help with my farm management decision making.

□ I can advertise the quality and management of my operation to others in the beef supply chain (i.e., processors, auctions and consumers).

□ I believe that sharing information along the supply chain makes the beef industry more competitive, which further benefits my operation.

□ I receive information from other beef producers and/or organizations in return (e.g.,, other commercial operation information for comparison or carcass data from processors).

□ I do not receive any benefits.

A18. If you do receive monetary benefits, approximately how much do you earn per animal per year by sharing your animal dataset?

□ $0 (I am not being paid to transmit this information)

□ Less than $5

□ Between $5 and $15

□ Between $15 and $25

□ Between $25 and $35

□ Between $35 and $45

□ Between $45 and $55

□ Between $55 and $65

□ Over $65

A19. Regarding the animal traits that you are already collecting for your own management decision making, how important are the following factors when deciding whether or not you are willing to share this information?

Potential Reasons	**Unimportant**	**Of little importance**	**Moderately important**	**Important**	**Very important**
The amount of cash compensation I receive	□	□	□	□	□
Certification that may help my operation to sell the beef/calves for a premium	□	□	□	□	□
Discounts for services that help with my farm management decision making	□	□	□	□	□

Showing the quality or management of my operation to others in the beef supply chain	☐	☐	☐	☐	☐
Making the beef industry more competitive, which can benefit my operation	☐	☐	☐	☐	☐
Receiving information in return	☐	☐	☐	☐	☐

A20. Regarding the animal traits that you are NOT CURRENTLY collecting, how important are these potential reasons for you to begin collecting this information and share it?

Potential Reasons	**Unimportant**	**Of little importance**	**Moderately important**	**Important**	**Very important**
The amount of cash compensation I receive	☐	☐	☐	☐	☐
Certification that may help my operation to sell the beef/calves for a premium	☐	☐	☐	☐	☐
Discounts for services that help with my farm management decision making	☐	☐	☐	☐	☐
Showing the quality or management of my operation to others in the beef supply chain	☐	☐	☐	☐	☐
Making the beef industry more competitive, which can benefit my operation	☐	☐	☐	☐	☐
Receiving information in return	☐	☐	☐	☐	☐

A21. How likely are you to share the following trait information?

Animal Trait Information	**Definitely no** (0% chance)	**Probably no** (25% chance)	**Not sure** (50% chance)	**Probably yes** (75% chance)	**Definitely yes** (100% chance)

Calving Ease	☐	☐	☐	☐	☐
Birth Weight	☐	☐	☐	☐	☐
Weaning Weight	☐	☐	☐	☐	☐
Yearling Weight	☐	☐	☐	☐	☐
Scrotal Circumference	☐	☐	☐	☐	☐
Gestation Length	☐	☐	☐	☐	☐
Productive longevity of cows	☐	☐	☐	☐	☐
Carcass Weight	☐	☐	☐	☐	☐
Marbling Score/% Intramuscular Fat	☐	☐	☐	☐	☐
Rib Eye Area	☐	☐	☐	☐	☐
Fat Thickness between 12^{th} and 13^{th} rib	☐	☐	☐	☐	☐
Meat Tenderness	☐	☐	☐	☐	☐
Horned or Polled	☐	☐	☐	☐	☐
Pigmentation & Coat Color	☐	☐	☐	☐	☐
Double Muscling	☐	☐	☐	☐	☐
Feed Efficiency/Dry Matter Intake	☐	☐	☐	☐	☐
Calf Health/Calf Survivability	☐	☐	☐	☐	☐
Docility	☐	☐	☐	☐	☐
Any Congenital diseases	☐	☐	☐	☐	☐
Any Other Diseases and Health Treatment	☐	☐	☐	☐	☐
Parentage Information	☐	☐	☐	☐	☐

Section B. Information Sharing

For this section:

If you agree with the idea that adopting genetic selection can benefit beef cattle breeders by effectively reducing the animal selection period and/or improving efficiency and productivity of the cowherd, then you understand the importance of genetic information. For commercial cow-calf producers, this improves their ability to make accurate breeding decisions and potentially reduce the production risk associated with breeding. From the Breeding Associations' perspective, gathering greater quantities of genetic data enables them to estimate more accurate EPDs. More precise EPDs facilitate improved breeds. Economically, this powerful genetic database will allow associations to become more competitive and lead to a larger market share for their members.

However, certain economic risks may be incurred by commercial cow-calf beef producers resulting in a reluctance to share their animal trait information with Breeding Associations, or other supply chain actors like feedlots or packing plants. For this reason, it may be necessary to create information sharing agreements that can compensate commercial cow-calf producers. Such compensation agreements can be designed to benefit all producers and lead to a more productive, profitable, and competitive beef industry for Alberta and Canada.

To complement an existing project by the government of Alberta, this project examines the feasibility of an information sharing agreement, which will potentially lead to improved productivity and profitability in the beef sector. We are interested in understanding how and how much streamlining the information sharing process can benefit all producers. Therefore, we are interested in your input, and our ultimate objective is to design an effective information sharing process that will improve the industry competitiveness.

In the following section, please answer the questions that pertain to the information sharing scenario detailed below:

To implement information sharing, a third party will be involved in the information sharing scenario. Collected data will be priced according to the quality of data delivered by the producers (e.g., the data will be verified to ensure they are complete and accurate). In order to participate and benefit in this scenario, commercial cow-calf producers will have to collect and submit comprehensive animal trait data. Under this information sharing scenario, producers will provide data to this third party organization for which they will be compensated by the third party with some agreed upon price. The third party will bundle and summarize the genetic data collected according to the breed. Breeding Associations may then purchase this summarized data from the third party.

B1. Think about how you acquire information to assist with your breeding and genetic selection decisions, please rate the importance of the following sources of the information.

Information Sources for Improving Genetic Selection Decisions	Unimporta nt	Of little importance	Moderately important	Important	Very important
Internet	◻	◻	◻	◻	◻
Specialized newspapers	◻	◻	◻	◻	◻
Other media (i.e., magazines or TV)	◻	◻	◻	◻	◻
Friends/family members who are experts in genetics	◻	◻	◻	◻	◻
Other producers	◻	◻	◻	◻	◻
Provincial expert workshops	◻	◻	◻	◻	◻
Consultants	◻	◻	◻	◻	◻
Seedstock providers (e.g., breeding association and purebred breeders)	◻	◻	◻	◻	◻
Academics/Genet icists	◻	◻	◻	◻	◻

For question B2:

Please consider these three categories of animal traits and answer the following questions.

A. Health/Diseases and Maternal Traits

- Calving Ease
- Birth Weight

- Weaning Weight
- Horned or Polled
- Pigmentation & Coat Color
- Double Muscling
- Calf Health/Calf Survivability
- Any Congenital diseases
- Any Other Diseases and Health Treatment

B. Production/Efficiency and Parentage Traits

- Yearling Weight
- Scrotal Circumference
- Gestation Length
- Productive longevity of cows
- Feed Efficiency/Dry Matter Intake
- Docility
- Parentage Information

C. Carcass Traits

- Carcass Weight
- Marbling Score/% Intramuscular Fat
- Rib Eye Area
- Fat Thickness between 12th and 13th rib
- Meat Tenderness

B2. (a) How likely would you be to collect and share the data in **group A** under this information sharing scenario if the third party were to offer compensation in the following amount (per head)? Please select a response for each payment amount (one response per row).

Compensation for per Head of Animal	**Definitely no** (0% chance)	**Probably no** (25% chance)	**Not sure** (50% chance)	**Probably yes** (75% chance)	**Definitely yes** (100% chance)
$0	□	□	□	□	□
$1	□	□	□	□	□
$2	□	□	□	□	□
$3	□	□	□	□	□
$4	□	□	□	□	□
$5	□	□	□	□	□
$6	□	□	□	□	□
$7	□	□	□	□	□

$8	□	□	□	□	□
$9	□	□	□	□	□
$10	□	□	□	□	□

B2. (b) How likely would you be to collect and share the data in **group A AND B** under this information sharing scenario if the third party were to offer compensation in the following amount (per head)? Please select a response for each payment amount (one response per row).

Compensation for per Head of Animal	**Definitely no** (0% chance)	**Probably no** (25% chance)	**Not sure** (50% chance)	**Probably yes** (75% chance)	**Definitely yes** (100% chance)
$0	□	□	□	□	□
$1	□	□	□	□	□
$2	□	□	□	□	□
$3	□	□	□	□	□
$4	□	□	□	□	□
$5	□	□	□	□	□
$6	□	□	□	□	□
$7	□	□	□	□	□
$8	□	□	□	□	□
$9	□	□	□	□	□
$10	□	□	□	□	□

B2. (c) How likely would you be to collect and share the data in **group A, B AND C** under this information sharing scenario if the third party were to offer compensation in the following amount (per head)? Please select a response for each payment amount (one response per row).

Compensation for per Head of Animal	**Definitely no** (0% chance)	**Probably no** (25% chance)	**Not sure** (50% chance)	**Probably yes** (75% chance)	**Definitely yes** (100% chance)
$0	□	□	□	□	□
$1	□	□	□	□	□

$2	☐	☐	☐	☐	☐
$3	☐	☐	☐	☐	☐
$4	☐	☐	☐	☐	☐
$5	☐	☐	☐	☐	☐
$6	☐	☐	☐	☐	☐
$7	☐	☐	☐	☐	☐
$8	☐	☐	☐	☐	☐
$9	☐	☐	☐	☐	☐
$10	☐	☐	☐	☐	☐

B3. How likely are you to share animal trait information with the following producers/breeding associations/organizations under this information sharing agreement?

	Definitely no (0% chance)	**Probably no** (25% chance)	**Not sure** (50% chance)	**Probably yes** (75% chance)	**Definitely yes** (100% chance)
Other producers	☐	☐	☐	☐	☐
Other organizations (e.g., TrustBIX)	☐	☐	☐	☐	☐
Own breeding associations	☐	☐	☐	☐	☐
Other breeding associations	☐	☐	☐	☐	☐

Section C.

C1. Do you have any comments or suggestions that you would like to share with us?

____
____
____
____
____
____
____

C2. In order to contact you if you win the prize draw, please answer ONE of the following questions (indicating which way you prefer us to contact you):

□ What is your email address? ____________________________

□ What is your phone number? ____________________________

C3. Would you like to receive a summary report of this research project?

□ No

□ Yes, same email address as C2

□ Yes, my email address is__________________________

We will use your contact information for the sole purpose of sending you a copy of the research project and contacting you if you win the prize draw. We will not share your data with anyone outside the project team.

The fact that you are reading this message indicates that you have completed our Questionnaire. We are very appreciative of your time to help with our research. Thank you for your contributing your valuable time and your honest information!

Ms. Freya Feng

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