

Determining dairy producers' willingness to pay for beef genetic attributes

by

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## **Abstract**

The purpose of this study was to quantify dairy producers' willingness to pay for beef EPD attributes in the development of beef x dairy calves. A discrete choice experiment was conducted as part of a larger production survey designed to better understand beef x dairy production and marketing decisions. This production survey highlighted key marketing decisions undertaken by beef x dairy producers such as motivations for incorporation, typical marketing practices, knowledge of EPDs, and sociodemographic characteristics. The discrete choice experiment represented a hypothetical scenario for dairy producers purchasing beef genetics in a semen straw. Survey participants were given the option of three straws with differing EPD attributes and a non-purchase alternative. Respondents were required to choose one of the four options for each scenario for a total of nine choice scenarios each. Attributes included price, calving ease direct EPD, marbling EPD, and dry matter intake EPD. Results were evaluated using both a standard conditional logit and a random parameters (mixed) logit. Marginal effects on probability of choice were evaluated as well as marginal willingness to pay estimates for select genetic attributes including calving ease direct, marbling, and dry matter intake.

Results reveal that dairy producers value terminal and management traits over maintenance traits. Producers are less likely to purchase straws with inferior calving ease traits and high prices. Alternatively, producers are more likely to purchase straws with superior marbling traits. Marginal willingness to pay (WTP) estimates demonstrate a strong producer WTP for superior marbling traits with positive and significant negative WTP for straws with inferior calving ease indicating that producers are wary of compromising management traits when seeking carcass benefits from a beef x dairy cross. Additionally, producer preferences

across EPD attributes are revealed to be heterogeneous across calving ease and superior marbling traits.

**Keywords:** Dairy, Beef, Beef x Dairy, EPDs, WTP, Discrete Choice

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# **Chapter 1 - Introduction**

The United States dairy industry is an economic force that accounts for 3% of the U.S. GDP with a total annual economic impact estimated at approximately 794 billion dollars (International Dairy Foods Association [IDFA], 2024). This places dairy as the third largest livestock sector in terms of cash receipts, with approximately \$45.9 billion in total receipts in 2023 (USDA ERS, 2023a). Major export markets include Mexico, Canada, and China with over 8 billion dollars in total export value in 2023 (USDA FAS, 2024).

Over the last century, technological advancements across the U.S. dairy herd have allowed dairy operations on aggregate to “do more with less”, resulting in a smaller, more specialized national dairy herd that produces more milk per cow than ever before (USDA ERS, 2023b). Unfortunately, despite the advantages provided by these advances in efficiency and productivity, modern dairy herds often face volatile and inconsistent returns that squeeze margins, forcing producers to adapt their operations to survive (Frisvold, 2020). Improving the quality and marketability of their excess dairy calves by incorporating beef genetics is one such adaptation that operators have conceived to improve their bottom line.

Calves produced on dairy operations that are not retained as replacement heifers, including bull or lower quality heifer calves, are commonly referred to as byproduct calves (Howard, 2022). Historically, these byproduct dairy calves have received substantial discounts throughout the value chain. Cattle feeders faced challenges associated with feeding lower entry weight calves that required more days on feed to finish, while simultaneously receiving lower prices from beef packers who heavily discounted dairy-type animals as poor yielding low-quality substitutes for traditional beef (Foraker et al. 2022a; Hoard’s Dairyman, 2024). Consequently,

demand for and price received by dairy producers for purebred byproduct calves was restrained. Recognizing this, producers adapted by incorporating beef genetics into their operations, thereby improving product quality and providing more marketable feeder cattle that better align with traditional beef cattle performance. Unfortunately, the slow commercial adoption of key reproductive technologies and above average national beef herd numbers meant there was little incentive for dairy producers to actively select traits that would improve their byproduct calf quality. Consequently, black hided beef x dairy calves were common, yet quality was not yet emphasized in this market (Peel, 2024a).

Fortunately, favorable market conditions, such as the historically low beef cattle herd numbers faced by today's market paired with advancements in key reproductive technologies, gave operators the opportunity to improve the marketability of these calves. Herd replacement considerations relaxed and greater pressure was placed on beef x dairy producers to supply high-quality beef. Instead of viewing these calves as mere byproducts, dairy operations could focus on improving the value of these beef x dairy calves through careful production decisions. One effective method of doing so is the selection of superior genetic traits using the widely adopted EPD index. As a well-established metric for advancements in beef genetics, expected progeny differences or EPDs, are well suited for dairy operators to improve the value of their byproduct calves by selecting sire traits that are more desirable to the beef market (Greiner, 2005). Unfortunately, market understanding is limited as no known studies are currently available that highlight dairy producers' preferences towards beef genetics.

This study explores dairy producers' willingness to pay for beef EPD attributes in a beef x dairy cross utilizing a discrete choice experiment. In addition, we explore beef x dairy producers

themselves including sociodemographic characteristics, operational characteristics, and adoption motivations to better understand beef x dairy production decisions.

## **1.1 Motivation**

Developing an understanding of beef x dairy producers' willingness to pay for select genomic attributes could be of interest to both beef and dairy producers. Dairy producers are the first to benefit as they are given the opportunity to measure their own WTP against that of their peers, thereby assisting price discovery within the market. For example, those producers paying a premium for a specific attribute that is undervalued in the market, as demonstrated by the results of this study, could be made aware of this discrepancy and refocus their selection process. This price discovery process benefits both dairy and beef producers alike as the supply of beef genetics in a beef x dairy market is ultimately reliant on genetics produced at the beef seedstock level provided in straws. If beef seedstock producers can better understand a standard dairy producer's willingness to pay for superior genetics, they may tailor their breeding and marketing objectives to better serve this emerging customer base and maximize the value of their products.

In addition to the direct benefactors of this study, indirect benefactors include beef x dairy calf buyers and their customers. In the United States, the majority of calves are produced through a production model that involves separating the byproduct dairy calf from the cow early and raising that calf separately on a diet of milk replacer. Unfortunately, while this process enables dairy operations to maximize per cow milk production, retaining these calves is a risky and expensive proposition (Creuzinger et al. 2021). Therefore, dairy operations are motivated to sell these calves as early as possible to avoid undue maintenance costs. These calves are typically marketed in three ways including 'wet', (i.e., before weaning), as background feeders, and as finished beef cross cattle sold through auction or direct sale (University of Wisconsin-Madison

Division of Extension, n.d.). As operators, backgrounders, feedyards, and auction barns are rewarded by the market for the quality of the calves they select, they are incentivized to choose cattle with more desirable traits to their primary market driving producer demand for superior beef genetics in a beef x dairy crossbred.

Ultimately, the purpose of this study is to benefit producers and other market participants by clarifying the demand for beef x dairy genetics. Whether through assisting price discovery or by guiding future research, the findings will assist producers in their decision making and inform the supply market. It is this premise that guides our examination of the willingness of dairy producers to pay for beef genetic attributes in their pursuit of a higher valued byproduct.

## **1.2 Purpose Statement and Objectives**

The purpose of this thesis is to quantify dairy producer's willingness to pay for beef genomic attributes across the United States. To accomplish this purpose, several objectives were undertaken, including:

- 1) Evaluating the economic drivers of development of beef x dairy animals including attributes desired by beef and dairy operators.
- 2) Exploring beef x dairy producers sociodemographic characteristics, adoption motivations, marketing practices, and knowledge of EPDs.
- 3) Quantifying dairy producers' willingness to pay for beef EPD attributes using a discrete choice experiment.

## **Chapter 2 - Background**

Beef x dairy crossbred production benefits dairy producers and beef x dairy consumers alike. Greg Henderson highlighted this sentiment in his “Beef x Dairy: Vision & Reality” piece describing the emergence of beef x dairy crossbreds as a “valuable opportunity and a challenge to the U.S. beef industry”. Beef x dairy crossbreds currently account for approximately 20.5% to 22.7% of total U.S. beef production (Li & Cabrera, 2019b). Understanding the factors that drive dairy producers to undertake beef x dairy production is crucial to understanding their willingness to pay for beef genetics as this demand is ultimately tied to the growth of beef x dairy acceptance and availability in the market. Therefore, we begin with a supply and demand perspective of the development of beef x dairy calves before proceeding to an outline of existing valuation literature from both the beef and dairy perspective. We conclude with an overview of the selected traits and their valuation.

### **2.1 Demand Perspective for Beef x Dairy**

Demand benefits afforded to beef x dairy producers include 1) the reduction of discounts applied at the packer level, 2) the protection of downstream markets by the incorporation of beef genetics, and 3) the boost in demand for beef x dairy from packers facing tight supply. These benefits are defined below.

According to the USDA Cattle Contracts library, U.S. beef packers currently assign a dairy-type discount between \$15 to \$40/ head reflecting the lower quality performance of purebred dairy animals. This discount incentivizes dairy producers and mid-market participants to adapt their production processes, if possible, to an avenue that is subject to a lower discount.

Incorporating beef genetics is one such avenue, as a beef x dairy cross receives a lower discount

of \$18.75 to \$20/head (USDA AMS, Sept. 2024). In adopting beef x dairy, producers are therefore offered insulation from the downside risk of marketing pure-bred dairy animals into the beef grid, while improving the marketability of the byproduct calves to their downstream markets.

In periods of surplus beef cattle, beef packers typically balk at lower quality Holstein cattle or refuse them outright (Schwab et al. 2024). A key example of this was the 2016 refusal by a Tyson processing plant in Illinois to purchase Holstein cattle that resulted in a 5.5% reduction in prices received for live Holstein prices (McKendree et al. 2020). Faced with an overnight shift in demand, producers who had previously adopted beef x dairy were in a more certain marketing position than their counterparts as packers showed less inclination to refuse dairy-type cross cattle. This is crucial as sellers of these calves are subject to slaughter level demand following the economic theory of derived demand (Tomek & Kaiser, 2014, pg. 25). This states that farm level demand is dependent on demand at the slaughter level that is in turn dependent on primary consumer demand. Therefore, while beef x dairy crossbreds may remain less desirable to packers than their pure-bred beef counterparts, operators can ensure that in the event of a packer's refusal to slaughter dairy calves, a market yet exists for their beef x dairy product.

Ultimately, market conditions have contributed significantly to the expansion of beef x dairy crossbreds. With beef cattle inventory at a 63 year low moving into 2024 and projected expansion unlikely to occur until 2026, market conditions are primed to accept beef x dairy crossbreds into the beef market (Tonsor, 2024; Peel, 2024b). Under these conditions, packers are faced with tighter supply forcing them to make allowances for alternative cattle, paying higher prices for calves that would typically be more heavily discounted against traditional beef.

Producers of beef x dairy calves are therefore primed to invest more heavily in their beef x dairy production decisions with expectations of returns exceeding additional management costs (Poock & Beckett, 2022). This is not to say that feeders are automatically profitable simply due to growth in demand for substitutable cattle. Beef x dairy animals present unique challenges to feeders seeking to efficiently feed these lower entry weight animals that are often subject to poor feed conversion rates and subsequently unpredictable average daily gain (Husz et al. 2024). Extending days on feed partially corrects this poor conversion rate yet incurs additional fees associated with yardage and health maintenance, necessitating that feeders are still careful in their purchasing decisions (Felix, 2022).

## **2.2 Supply Perspective for Beef x Dairy**

Supply benefits that have allowed the expansion of beef x dairy as a legitimate market include 1) the renewal of multi-trait selection, 2) the introduction of sexed semen to the market and 3) the increased availability of superior beef genetics. These benefits are defined below.

Production of dairy calves across the globe is achieved almost exclusively via the use of thawed frozen semen through artificial insemination (AI) (Holden & Butler, 2018). Ultimately, supply of superior beef genetics begins at the seedstock provider who provides products differentiated by the merits of the genetics they produce. Operators will choose the supplier and the product that best suits their production and management capabilities. Unfortunately, this process is not infallible as the dairy industry has long faced systemic issues with declines in general animal health as the industry sought to maximize their milk output using single-trait selection, unwittingly contributing to significant declines in herd fertility as milk production grew (Berry et al. 2014; Oltenacu & Broom, 2023). A renewed focus on multi-trait selection aided by the increased availability of reproductive technologies including sex-sorted semen, in

vitro fertilization, availability of superior beef semen, and embryo transfer all contributed to a general increase in fertility across the industry (Canovas et al. 2017; Holden & Butler, 2018; Miller, 2022). As fertility has gradually improved, the need for replacement heifers has relaxed as fewer head are required per breeding season to maintain herd numbers, allowing producers to shift their focus towards improving the quality of their dairy replacement and beef x dairy calves as separate enterprises (Berry, 2021).

Sexed semen has been particularly instrumental in enabling operators to improve the quality of their byproduct calves (University of Wisconsin-Madison Division of Extension., n.d.). The incorporation of sexed semen allowed operators to preplan the proportion of heifers and steers provided by the breeding program. This practice allows producers to reduce the number of residual beef x dairy steers bred for milk production traits (Henderson, 2022). Dal Zotto et al. (2009) argued that the development of beef x dairy was hindered prior to the introduction of sexed semen due to the negative physiological relationship between systems that support either carcass or milk production characteristics (Cartwright, 1983). The emergence of sexed semen technology on the open market allowed operators to preplan the proportion of heifers and steers, reducing instances of unwanted bull calves in the dairy replacement herd and unwanted heifer calves in the beef x dairy population. As operators are rewarded by the quality of the calves they produce and beef x dairy steers can be treated closer to traditional beef in the yard, both dairy producers and cattle feeders are better off (Cabrera, 2022; Ettema et al. 2017).

Another key contributor to the supply of beef x dairy has been the increased availability of superior beef genetics. As technology has improved, operators have been able to inexpensively incorporate top sire genetics, boosting the value of the underlying progeny (McCulloch et al. 2013). It is not surprising then that Basiel and Felix, (2022) attributed the growth in beef semen

sales to growth in demand from the dairy industry. Dairy operations are simply increasing the utilization of superior beef genetics in their herds to produce calves that are more suitable to the U.S. beef market, raising the potential of higher value surplus calves, while maintaining quality and grade characteristics (Ettema et al. 2017; Keane, 2011; Martin et al. 2021).

The private firm CattleFax has projected beef x dairy cattle numbers will reach four to five million head by 2026 (Brooks, 2024). As these numbers grow, producers will need to be more careful in their sire selection to compete and garner the highest premium available. Active selection of EPDs is one method of staying competitive.

EPDs are a well-established metric used in informing buyers of genetics of the relative advantage of utilizing a certain straw of semen or bull relative to their counterparts. These expected progeny differences represent the sum of all available information about potential progeny given in the form of a prediction of the genetic merit of breeding a specific animal (Thrift & Thrift, 2006). EPDs are utilized in all major beef breed associations in the U.S., such as the Angus Association, Hereford Association, and the Simmental Association. These EPDs are available for traits including production, management, maternal, carcass, and dollar index value attributes ranging from relative calving ease (CED) to ribeye area (RE). The widespread adoption of this system and proven effectiveness of the use of these values to advance beef genetics makes these a logical choice for dairy producers to select attributes that benefit their beef x dairy crosses in the beef market. For our purposes, we utilize the American Angus Association's EPDs following Poock and Beckett, (2022) who emphasized the role of Angus genetics in the beef x dairy cross, claiming that approximately 95% of crossbred beef on dairy is derived from Angus semen.

In summary, beef x dairy production benefits both dairy producers and beef consumers alike presenting a “valuable opportunity and challenge” to the U.S. beef industry (Henderson, 2022). Current supply and demand factors have provided an opportunity for beef x dairy success and advancement. As beef x dairy is primed to take advantage of these favorable market conditions, producers are focusing on improving these crossbreeds. A key method of doing so is the active selection of EPDs. We therefore proceed with an outline of available literature concerning EPD selection in both the beef and dairy industry.

### **2.3 Beef Cattle Literature**

This study uniquely incorporates both beef and dairy literature, balancing industry expectations for beef and dairy production. This is particularly important as little is understood about the dairy industry’s WTP for beef attributes. Given the dearth of information about dairy producer preferences, examining beef producer preferences provides guidance and highlights those traits that beef producers are rewarding. We discuss and highlight preferences for several of these key traits below.

A review of the beef EPD WTP literature identifies several key categories. Chief among these are the production traits that may be divided into birth to yearling gain measures and feeding performance. Birth to yearling gain production traits include calving ease direct, birth weight, weaned weight, and yearling weight EPDs. Foremost of these birth-to-yearling gain production traits appears to be calving ease direct EPDs (CED), which has been shown to consistently drive sire value across studies that together encapsulate preferences from across the U.S. (Boyer et al. 2019; Hoffman, 2019; Griffith et al. 2020; Joseph et al. 2024; Melchor, 2024; Smith et al. 2023; Smith, 2020; Vestal et al. 2013). Birth weight EPDs (BW) are also documented as a significant driver of sire prices though studies report conflicting effects on

producer WTP. While most assert that increases in birth weight decrease producer WTP (Brimlow & Doyle, 2014; Melchor, 2024; Smith, 2020; Tejeda et al. 2018; Turner et al. 2004; Vestal et al. 2013), others find that increased BW increases producer WTP (Kessler et al. 2017; Parcell et al. 2005; Tejeda et al. 2018). Given the close correlation demonstrated between birth weight and calving ease, these differences may likely be attributed to either commercial or seedstock producers. Commercial producers would be more interested in reducing management costs associated with pulling calves while seedstock producers may emphasize premiums gained by providing larger more mature animals on sale date. Regardless of segmentation, improvements in yearling weight EPDs (YW) consistently increase WTP (Kessler et al. 2017; Melchor, 2024; Parcell et al. 2005; Tejeda et al. 2018; Turner et al. 2004; Vestal et al. 2013). Overall, sire selection studies indicate that beef producers prioritize addressing calving difficulties as shown by emphasis on CED and BW before considering performance or carcass improvements (YW).

Beyond growth production traits, several maternal characteristics are rewarded by producers. The maternal milk EPD is foremost among these as this EPD exhibits significance in shaping producer preferences across the available literature. However, the marginal effect of improvements in the milk EPD is unclear with the larger proportion of literature asserting that WTP is increased as the maternal milk EPD improves (Franken & Purcell, 2012; Jones et al. 2008; Joseph et al. 2024; Parcell et al. 2005; Smith et al. 2023; Tejeda et al. 2018; Turner et al. 2004). Fortunately, this is unlikely to drive dairy producers' preferences as beef x dairy calves are being sold as terminal crosses not as breeding stock.

While both maternal and production traits are rewarded in beef EPD WTP literature, carcass characteristics cannot be ignored. Producers are clearly emphasizing carcass merit as literature

has reached a consensus on the value of improving carcass characteristics such as marbling and ribeye area. Improvements in marbling traits drive producer preferences across the literature, increasing WTP for sires (Franken & Parcell, 2012; Melchor, 2024; Smith, 2000; Vestal et al. 2013). The same improvements in WTP are found in incorporating superior ribeye area EPDs (Franken & Purcell, 2012; McDonald et al. 2010; Melchor, 2024; Smith et al. 2023; Smith, 2000; Stephens, 2015; Thompson et al. 2022; Turner et al. 2004; Vanek et al. 2008).

Understanding how beef producers value EPDs provides a useful framework, but these findings must be interpreted in the context of beef operations that vary across regions and goals. Unlike traditional beef producers, dairy producers selecting EPDs for the development of beef x dairy calves may value and prioritize these traits differently. To address this, we turn to specific beef x dairy literature to guide relevant trait selection.

## **2.4 Beef x Dairy EPD Literature**

To the best of our knowledge, no prior literature explores dairy producer's willingness to pay for genomic attributes in beef x dairy crossbreeding. However, extensive research has demonstrated the economic benefits of incorporating beef genetics into surplus dairy calves from a performance standpoint. While producers have access to research on beef x dairy performance compared to purebred dairy calves, less literature is available on how dairy producers select these EPD attributes. We therefore outline those traits identified in available literature as being desirable to dairy operators to narrow the number of traits under consideration.

### **Calving Ease Direct**

Beef x dairy cattle are commonly associated with production challenges including instances of dystocia (i.e., birthing complications), and a higher prevalence of liver abscesses. While liver abscesses are generally understood to result from prolonged feeding of a high concentrate diet

(Foraker et al., 2022a), dystocia instances are heavily influenced by sire selection. This is crucial as profitability ultimately depends on the dairy cow, bred either to a beef or dairy sire, calving with little to no complications that may place the health of the cow and/or calf in jeopardy. Dairy producers may mitigate these instances of calving difficulties by selecting sires with superior calving ease direct EPDs.

Berry & Ring, (2023) emphasized the role that calving ease has in the forefront of any additional selection decisions in their exploration of the impact of selection for calving ease and beef production traits versus calving ease traits alone. Their results demonstrated that incorporating dairy beef merit indices focused on these beef x dairy improvement traits resulted in a 3 to 5% increase in dairy herd profit at the marginal cost of increases in instances of calving difficulties. Accordingly, producers may select superior terminal characteristics but will need to weigh the role of calving management against marginal increases in carcass value. Berry et al. (2019) highlighted this central tradeoff between calving ease and carcass traits. The authors asserted:

“The generation of calves that are expected to excel in efficiency of growth and carcass merit must not be achieved to the detriment of the dairy female and her ability to calve and re-establish pregnancy early postcalving without any compromise in milk production.” (pg. 1)

Given these findings, we propose including CED as a key production trait for dairy producers aiming to balance calving ease with carcass improvement without compromising animal health or management.

## **Marbling**

Marbling is another key trait for consideration in beef x dairy sire selection. Multiple papers have confirmed that genetic selection may be used to improve carcass qualities within a beef on dairy cross (Martin et al. 2020; Martin et al. 2021; Foraker et al. 2022b). Currently, beef x dairy retail meat cuts account for over 30% of the USDA prime grade. These cuts are virtually impossible to distinguish from retail beef cuts in taste, tenderness, flavor, juiciness, or color for most consumers. Foraker et al. (2022b) emphasized the need to improve beef x dairy dressing percentage (i.e., conversion of live weight to carcass weight), and the convertibility of carcass weight into saleable cuts. To do so, they recommended that producers focus on marbling, total carcass muscling and red meat yield thereby maximizing carcass value.

Foraker et al. (2022a) also compared feedlot and carcass performance between beef and purebred dairy cattle, confirming lower dressing percentages in dairy cattle compared to a traditional beef animal. Dairy animals, on average, had 18% lower 12<sup>th</sup> rib fat thickness than beef cattle producing less than half of the yield grade four carcasses, while exhibiting 5% less ribeye area than traditional beef cattle. Given these deficiencies in relative ribeye area, producers may very well be anticipated to actively select ribeye area EPDs, yet additional carcass characteristics may be better suited to beef x dairy improvement. Tatum et al. (2006) highlighted the value of including carcass attributes in their comparison of yield grade and quality grade-based grids to determine the relative importance of carcass weight, quality grade, and yield grade in valuation of beef x dairy animals. Their findings supported the central importance of carcass weight in determining carcass value on either grid when the choice-select spread was less than \$10. As this spread increased, quality grade replaced carcass weight as the main driver of grid value. Given that quality is dependent on marbling, in instances where the spread is greater than \$10, dairy

operators would then be best suited to select sires geared towards improving marbling.

Alternatively, when the spread is below \$10, dairy producers should focus on driving carcass weights, thereby overcoming the losses in dressing percentage brought about by beef x dairy.

Given the available literature on carcass deficiencies in beef x dairy, we propose prioritizing ribeye area and marbling traits in sire selection. While carcass weight EPDs are also prioritized in instances of low choice-select spreads, given the strong correlation that exists between carcass weight and birth through yearling weight, operators that focus exclusively on carcass weight will have to forgo calving ease benefits. By doing so, dairy operators would be prioritizing carcass terminal traits over additional management costs associated with dystocia – something that dairy operators are likely unwilling to do. Though beef x dairy animals display smaller ribeye areas in comparison to the purebred beef animal and selection for this trait may benefit the premiums awarded to beef x dairy producers, we argue that, as quality grade is ultimately the driver of grid value, producers will view marbling as the more crucial selection criterion.

### **Dry Matter Intake**

Feed efficiency is another relevant trait in beef x dairy selection, directly impacting production costs and profitability. As feed is a major component of variable costs in both dairy and beef operations, improving the feed efficiency of beef x dairy calves can significantly lower cost of gain for downstream markets. Pryce et al. (2014a) examined dry matter intake (DMI) and residual average daily gain (RADG) as measures of feed efficiency that are popular in the development of breeding objectives that focus on reducing feed costs. Since DMI and RADG are highly heritable and correlated, careful genetic selection can drive improvements in feed efficiency reducing operational feed costs for beef x dairy calves.

When considering which of these feed efficiency measures is better suited to driving improvements in feed efficiency, Pryce et al. (2014a) asserted that DMI is preferable to RADG when there is uncertainty in genetic parameters. This is largely due to the unknown factor of body tissue mobilization given variable dam genetics that makes average daily gain difficult to predict. Accordingly, DMI would be preferential for producers representing a wide range of operations. In addition, DMI is considered more accurate as a genetic predictor of feed efficiency of potential progeny. (Pryce et al. 2014a)

Pryce et al. (2014b) sought to validate the accuracy of genomic prediction for both residual feed intake and dry matter intake using Australian dairy data. Higher realized accuracies were present in DMI across their study which was expanded to incorporate New Zealand, Australia, the UK, and the Netherlands. Overall, their study illustrated that selection for dry matter intake and residual feed intake is feasible as a selection criterion with consistent and accurate advances across countries. This evidence of the feasibility and necessity of focusing selection decisions on DMI suggests that producers may already be actively selecting for this attribute. Given the economic significance associated with improvements in feed efficiency and established heritability/ significance of DMI, we argue that DMI should be incorporated into our study as a key trait driving dairy producers' willingness to pay for beef genetics.

To summarize, given the traits identified in both beef and dairy relevant producer preference literature, we may prioritize several key EPD attributes for selection including calving ease direct, dry matter intake, and marbling. Given that Halfman & Sterry, (2019) confirmed cost, calving ease, and marbling as key EPD criteria for dairy producers, we hypothesize that dairy producers will look to reward these attributes over other possible attributes. Additionally, we expect that a relative advantage in these attributes should result in an increase in their willingness

to pay for an individual straw of beef semen. It is the focus of this study to determine the relative increase in value associated with an increase in these desirable attributes.

## Chapter 3 - Data and Methodology

To assess the willingness of producers to pay for beef genetics, a survey was conducted that included a stated choice experiment to examine dairy producers' willingness to pay for beef EPD attributes. We outline the methodology utilized in this process below, beginning with an examination of appropriate methodology for valuing product characteristics before proceeding with an explanation of our model. This system of equations progression follows Schumacher et al. (2012) in the development of the model specification. We then describe the design of our discrete choice experiment as well as the production survey that accompanied this experiment. Distribution of this survey and its success is discussed before concluding with a discussion of minimum sample size requirements.

### 3.1 Methodology Review

Ladd and Martin (1976) described all products as a collection of characteristics that drive product value through the marginal monetary value afforded to the buyer. Specifically, they define the price of a product as the weighted sum of the monetary value of the characteristics of that product implying that as these characteristics are changed, demand for the product itself is modified. Quantifying this monetary value and the subsequent effect on demand has subsequently become the topic of a multitude of research papers considering characteristics of products ranging from beef backgrounding inputs to housing characteristics. As early as 1935, the 'hedonic' model, coined by Andrew Court, has answered the need for marginal valuation of characteristics by examining the weighting of these characteristics on the final value of the product (Goodman, 1998). This may be described empirically using the following equation:

$$p_i = \sum_j B_j X_{ji} \quad (1)$$

This specification equates the transactional price  $p_i$  to the sum of the marginal implicit value of the characteristics  $B_j$  for the individual characteristic  $j$  and the characteristics themselves  $X_{ji}$  for transaction  $i$ . This hedonic model is extremely popular and extensively used throughout the literature. Requiring only transactional data and individual characteristic data, the majority of literature valuing EPDs applies hedonic model methodology. This is done through regressing bull auction data using price as a dependent variable against characteristics such as lot number (i.e., the order they enter the sale), EPD values, ages, and regions. This approach works well for markets that have readily available data for products possessing these characteristics, such as beef bull sales.

While hedonic models are useful in revealing preferences through empirical data, such models are poorly suited for applications with limited publicly available market data. The market of beef genetics used in the dairy industry reflects such a market with limited information. This poor data availability is likely tied to the difficulty and cost of procuring such data. For instance, a dairy operator may attend a beef sire sale or purchase a given straw online, but purchasers may not be clearly defined as a dairy or beef operator, confusing WTP interpretations and leading to biased results. For operators that produce both dairy and beef, records are even more opaque. The same issues are encountered in valuation of the beef x dairy crosses themselves. For instance, auction sites like Superior Livestock Auction are beginning to list cash prices for beef x dairy cattle sold on their platform; however, limited information is available on their actual genetics, with the majority of entries merely laying out a list of bulls, treatments, and price received (Superior Livestock Auction, n.d.). Of the data available, most is proprietary in nature and would be subject to careful interpretation based on geographical scope, scale, and control

variables. Ultimately, much work is required to update existing public records to fully understand WTP for genetics using this framework.

Azevedo et al. (2003) illustrated that a strong degree of correlation exists between stated and revealed preferences. While revealed preferences rely on empirical data analysis such as hedonic modeling, stated preference measures are reliant on survey instruments, such as discrete choice experiments to approximate an individual's willingness to pay for an attribute. This methodology enables researchers to survey the producers themselves without undue stress on the producer or undue cost to the researcher. Discrete choice experiments attempt to model the decision making that a producer faces in a typical market transaction by providing the choice between several products with a variation of price and non-price attributes. (Lusk & Norwood, 2005)

We elected to use a choice experiment to elicit dairy producers' willingness to pay for beef EPDs when developing beef x dairy crosses. This follows similar studies done by Schumacher et al. (2012), Vestal et al. (2013), Smith et al. (2023) and others who elicited producer perspectives using a discrete choice model to determine producers' willingness to pay.

### **3.2 Discrete Choice Modeling**

Given that rational decision makers maximize their utility by choosing the product with the collection of characteristics that maximizes their individual satisfaction, we can use the random utility model to define a producer's utility function as the following: (McFadden, 2001)

$$U_{ijt} = V_{ijt} + e_{ijt} \quad (2)$$

This model indicates that individual utility  $U_{ijt}$  for producer  $i$  of employing option  $j$  in choice situation  $t$  is a summation of a deterministic utility component ( $V_{ijt}$ ) and a stochastic error component ( $e_{ijt}$ ). Producers will select the choice between alternatives that maximizes their utility, which we observe as a choice,  $y_i$ , usually specified as a discrete binary outcome given the

discrete choices available i.e., the choice of straws. That is, the binary outcome of an individual's choice given their utility function may be written as:

$$y_{ijt} = \begin{cases} 1 & \text{if } U_{ijt} > 0 \text{ (Straw X is selected)} \\ 0 & \text{Otherwise} \end{cases} \quad (3)$$

Producer utility is then observable only in the systematic component ( $V_{ijt}$ ). Assuming the systematic component of a producer's derived utility is a linear parameterization of the characteristics of the product, we can specify  $V_{ijt}$  as:

$$V_{ijt} = \beta_1 X_{ijt,1} + \beta_2 X_{ijt,2} + \beta_3 X_{ijt,3} + \dots + \beta_n X_{ijt,n} \quad (4)$$

Where  $B_n$  represents the marginal utilities of the  $X_{ijt,n}$  attribute characteristic presented to producer  $i$  for option  $j$  from the choice situation  $t$ .

Following Schumacher et al. (2012), we consider both a multinomial logit (MNL) and a random parameters logit (RPL) framework, as both are commonly employed in choice experiment estimation. The standard MNL model operates under the assumption of preference homogeneity and independence of irrelevant alternatives. Estimates indicate the probability that an individual chooses a particular alternative. Therefore, the probability of producer  $i$  choosing option  $j$  given choice set  $t$  is specified as follows: (McFadden, 2001)

$$\pi(Y_{ijt} = 1 | V_{ijt}) = \frac{\exp^{(v_{ijt})}}{\sum_j \exp^{(v_{ijt})}} \quad (5)$$

Alternatively, the RPL model allows the preferences of the sample population to vary to account for preference heterogeneity within a surveyed population. This approach tests preference heterogeneity across the non-price attributes by specifying them as random parameters following a standard normal distribution. This relaxes the assumption of independence of irrelevant alternatives allowing the presence of other options to influence the odds of a producer choosing one option over another. Given this more closely represents actual

decision making, the RPL model is considered better suited for WTP estimation. This approach yields a coefficient estimate for both the mean and standard deviation of the parametric distribution, which taken in conjunction may describe both the direction and distribution of preferences. These estimates may be used to identify the proportion of the respondent population that are positively valuing an attribute, while assisting in identifying possible subsets of the population within responses. The specification for the probability of a producer  $i$  choosing option  $j$  given choice set  $t$  given random parameters is given as: (McFadden & Train, 2000)

$$\pi_{ijt} = \int L_{ijt}(B_n)f(B_n|\theta)dB \quad (6)$$

The random parameters logit function is then the integral of the multinomial logit  $L_{ijt}$  with the coefficient  $B$  as a random variable varying with respect to the probability density function  $f(B_n|\theta)$ , which is often assumed to be normal.

An additional specification applied to this study is the structuring of contrast coding. As the EPD attributes are grouped into levels, interpretation should be done from a baseline, particularly since EPDs are present at some baseline level in every straw purchase. Contrast or effects coding accounts for this interpretation uncertainty by allowing the researcher to interpret the marginal effects of deviations from the baseline by specifying the baseline as a fixed point of the groups under consideration (Alkharusi, 2012). This is accomplished by recentering the variables around a common mean allowing interpretation to be made from the baseline intercept of the model (Piccinini, 2016). Attributes are weighted towards 0,1, or -1 depending on the perceived benefit of the move. For instance, to effectively code the superior calving ease trait, superior traits are coded 1 while neutral or inferior traits are coded 0 and the baseline “None” option is specified as -1. This necessitates that a base of comparison for non-price attributes be set which was

determined to be the intermediate levels set in the choice experiment design. Accordingly, we specified final producer utility as the following.

$$\begin{aligned}
U_{ijt} &= \beta_{None}None_{ijt} + \beta_{Price}Price_{ijt} + \beta_{High\_Marb}High\_Marb_{ijt} + \beta_{Low\_Marb}Low\_Marb_{ijt} \\
&+ \beta_{High\_DMI}High\_DMI_{ijt} + \beta_{Low\_DMI}Low\_DMI_{ijt} + \beta_{High\_CED}High\_CED_{ijt} + \beta_{Low\_CED}Low\_CED_{ijt} \\
&+ e_{ijt}
\end{aligned} \tag{7}$$

Given that producers follow this empirical specification, marginal willingness to pay (WTP) for individual attributes therefore consists of the ratio of the attribute coefficient to the price coefficient. This may then be described empirically as the following:

$$WTP = - \left( \frac{B_n}{B_{Price}} \right) \tag{8}$$

The marginal WTP measure provides a measure of producers' preferences towards attributes. The marginal WTP may be interpreted as the benefit/ discount associated with an advancement to the next level as specified in the producer utility function above. For instance, a marginal WTP of \$3.00 for a high marbling attribute is indicative of an additional \$3.00 awarded for superior marbling as specified by the deviation from the baseline established in the effects coding. Final interpretation of the value of the attribute may then be considered as the sum of the baseline price and the marginal WTP estimate. Accordingly, a \$3.00 marginal WTP actually indicates a final product WTP estimate for that attribute of \$18.00.

All econometric models were estimated in R software using the RChoice package. We first estimated a standard multinomial logit function with effects coding before performing the same estimation on a random parameters (mixed) logit function. For this model, we specified 2500 Halton draws specifying normal distributions for all non-price attributes. Model fit for these estimations was measured using the McFadden pseudo  $R^2$  approximation. This

approximation is traditionally used as a means of modeling regression fit for log likelihood estimations (McFadden, 1972). This may be described empirically as:

$$McFadden \text{ psuedo } R^2 = 1 - \frac{LL_{Model}}{LL_{null}} \in [0,1] \quad (9)$$

This suggests that model fit may be approximated using the ratio of the log likelihood estimates of the estimated model ( $LL_{Model}$ ) and the null model ( $LL_{null}$ ). The null model is a function of the estimation of the model using only the intercept as a regressor. This measure may be interpreted therefore as the relative advantage in estimation power of the estimated model over the null. As psuedo  $R^2$  values increase, model fit is improved.

### 3.2 Choice Experiment Design

In designing our discrete choice experiment, we were particularly sensitive to the boundaries of elicitation of WTP by a survey method, i.e., producers are busy and unwilling to complete unnecessarily long or difficult survey instruments. The tradeoff between choice experiment survey complexity, respondent fatigue, and subsequent response rate is well documented (Lusk & Norwood, 2005). We therefore elected to elicit marginal WTP for beef sire genetics using only those price and non-price attributes of primary importance for producers to consider as suggested by the literature. Accordingly, we included calving ease direct, dry matter intake, marbling, and price within our choice experiment with levels set by the American Angus Association EPD index guided by available relevant literature.

Due to the prevalence of EPDs across the beef industry and their counterpart in the dairy industry, i.e., estimated breeding values (EBVs), we may expect the modern producer to not only understand but be actively involved in utilizing EPDs on their own operations. Under the assumption that the typical producer is familiar with the concept of EPDs, we used actual values. Smith et al. (2023) and Vestal et al. (2013) took this approach in their methodology laying out

relevant EPDs in determining willingness to pay by utilizing the American Angus Association's (AAA) EPD percentile index. This index describes the percentile rankings of EPDs within their association on a biannual basis allowing producers to compare their EPD performance against that of the entire U.S. based breed organization. As a dominant breed in beef x dairy crosses in the United States, the AAA's EPDs are widely available for their producers to consult when making breeding selection decisions providing us a set of relevant representative values that may be incorporated into the choice experiment. Specifically, they utilized levels set at low, medium, and high values at the 65<sup>th</sup>, 35<sup>th</sup>, and 5<sup>th</sup> percentiles of the AAA's percentile index, publicly available through the American Angus Association. To make the low, medium, and high levels more apparent to producers, we employ levels set at the 95<sup>th</sup>, 60<sup>th</sup>, and 1<sup>st</sup> percentiles for each of the non-price EPD attributes based on the Spring 2024 American Angus Association percentile index. This percentile breakdown is included in Appendix A.

Basiel and Felix, (2022) found the price of beef straws used for artificial insemination to be comparable across beef and dairy operations. It is this correlation that we build on to set relevant price ranges. Basiel and Felix, (2022) and Li and Cabrera, (2019b) simulation-based models set beef semen prices at \$15/dose. To add depth to the willingness to pay estimates we employ three levels set at \$10, \$15, and \$20 which are implemented based off a \$5 variation from the average received in the papers above. The low, medium, and high values used for each attribute in this choice experiment are provided in Table 1.

**Table I: Choice Set Attributes evaluated by Dairy Producer Respondents**

| Attribute           | Alternatives                                                |
|---------------------|-------------------------------------------------------------|
| Price               | \$10.00 per straw<br>\$15.00 per straw<br>\$20.00 per straw |
| Calving Ease Direct | High: +17<br>Medium: +5<br>Low: -2                          |
| Dry Matter Intake   | High: -0.72<br>Medium: +1.21<br>Low: +1.99                  |
| Marbling            | High: +1.61<br>Medium: +0.48<br>Low: +0.03                  |

With the intention of making the choice survey as manageable, straightforward, and realistic to real world choices faced by producers as possible, we asked respondents to consider buying straws from beef sires on the open market from a reputable seller with three possible options: Straw A, Straw B, or Straw C. In addition, an option of “I would buy something else” was offered. Each of these bull sire genetic options displayed levels for price, calving ease direct, dry matter intake, and marbling. This combination of choices available to the producer thus had  $3^3 \times 3^3 \times 3^3 \times 3^3 = 531,441$  possible outcomes under a full-factorial design with three levels for the price and non-price attributes. As a means of lowering required responses, we followed Kuhfeld et al. (1994) in employing a fractional factorial design that resulted in a consolidated design of 27 choice sets. This was further consolidated by employing a block system to break up the choice sets into three blocks of nine choice sets to help reduce survey fatigue. These blocks were randomized in the survey software to present one of the available blocks to each respondent.

Given the randomized nature of the blocking output by SAS, the options were themselves not randomized in the Qualtrics software.

Figure 3-I demonstrates an example choice set presented to a respondent of which nine per block are presented to each respondent. Within the Qualtrics online survey software, the producers were given identical information in each choice set while the levels set for each straw were variable as outlined in Table 1. Respondents were able to select the straw that best suited their operation including an opt out option to more closely represent producer decision making in a non-hypothetical setting.

**Figure 3-I: Sample Choice Set from Beef x Dairy Survey**

|                                                                                                                                                                                                                                  |                          |                          |                          |                                                                                                       |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------------------------------------------------------------------------|
| Please consider the following choices. Assume that you are purchasing Angus genetics from a reputable seller to cross with a dairy dam to produce beef x dairy calves and the three options are identical in every other aspect. |                          |                          |                          |                                                                                                       |
| <i>(Please select the semen straw that you would purchase given price and the EPD attributes given.)</i>                                                                                                                         |                          |                          |                          |                                                                                                       |
|                                                                                                                                                                                                                                  | <b>Straw A</b>           | <b>Straw B</b>           | <b>Straw C</b>           | If these were the only options available, I would buy something else.<br><br><input type="checkbox"/> |
| <i>Price (\$/Straw)</i>                                                                                                                                                                                                          | \$15                     | \$20                     | \$10                     |                                                                                                       |
| <i>Calving Ease Direct</i>                                                                                                                                                                                                       | +17                      | +5                       | +17                      |                                                                                                       |
| <i>Dry Matter Intake</i>                                                                                                                                                                                                         | -0.71                    | -0.71                    | -0.71                    |                                                                                                       |
| <i>Marbling</i>                                                                                                                                                                                                                  | +1.56                    | +1.56                    | +1.56                    |                                                                                                       |
|                                                                                                                                                                                                                                  | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |                                                                                                       |

The statistical software SAS was utilized to consolidate the full factorial design to a fractional factorial design and impose blocking on the available combinations. This process is intended to optimally design a discrete choice experiment by maximizing the efficiency of the combination of choices given to individuals and balancing each attributes statistical power in available choices (Lusk & Norwood, 2005). This is often measured using a D-efficiency score.

This D-efficiency score measures the quality of a design as a function of the geometric mean of the eigenvalues of the matrix of attributes employed in the DCE (Lusk & Norwood, 2005).

Empirically, this may be described as:

$$100 \frac{1}{N|(X'X)^{-1}|^{1/A}} \in [0,100] \quad (10)$$

Where the geometric value of eigenvalues is  $(X'X)^{-1}$  as a function of the attribute's information matrix  $(X'X)^{-1}$ , where  $X$  is the attributes under consideration i.e.,  $X = [\text{Price, CED, DMI, Marb}]$ .  $N$  describes the number of observations in the design, while  $A$  describes the combination of the attribute number and corresponding levels. A perfect D-efficiency score is indicative of a perfectly orthogonal and balanced design; however, this is often impractical in real world applications. A fractional factorial design identifies a subset of the attribute combinations so that main effects are captured in the model design, reducing the number of necessary combinations (Lusk & Norwood, 2005). Utilizing this methodology, the combination of choices was thereby reduced to 27 choice sets. This approach yielded a D-efficiency score of 92.67% implying a relatively efficient model. Appendix C contains the coding for this process in SAS.

However, additional blocking was employed to reduce the number of choice sets presented to each respondent. This lowered the efficiency of the model yielding a 88.37% D-efficiency score, which is still deemed acceptable as respondent burden is lowered as a result. SAS was used to specify the blocking output as illustrated in Appendix D.

### 3.3 Production Survey

We encapsulated the discrete choice model described above in a larger production survey to improve our understanding of beef x dairy producers including their sociodemographic characteristics, adoption motivations, marketing methods, and EPD knowledge. For that purpose,

we included within the survey several questions designed to attain pertinent producer information including farmer sociodemographic characteristics, operation characteristics, motivations for adoption of beef x dairy cattle, average weight sold to market, and primary market for their beef x dairy calves.

Sociodemographic characteristics are captured in order to understand the representativeness of our sample as well as provide insights into who is undertaking adoption of beef x dairy. We begin with multiple key sociodemographic characteristics that are widely adopted in literature to describe producers, managers, and consumers including age (years), education (high school to advanced degree), and experience (years milking). In addition, operational characteristics are also surveyed including state location and operational size as shown by number of head. These are typical measures employed by the USDA to stratify and describe dairy operations. (Gillespie et al. 2024; MacDonald et al. 2016; USDA NASS, 2024) Both operator and operational characteristics are captured using a binned response method in order to reduce survey fatigue as much as possible.

In addition to sociodemographic characteristics, we also consider the motivations behind adopting beef x dairy practices. These motivations have been defined in several papers that were consolidated by Berry, (2021) and which are demonstrated in Table III. Incorporation of these driving motivations will be useful to determine which motivations are primarily associated with an increase in willingness to pay for certain attributes.

The retention length of beef x dairy cattle on an operation is also considered. This retention length answers the following key consideration: How long are beef x dairy producers retaining ownership of these animals? In particular, it is important to understand if they are selling at their earliest convenience or retaining ownership to capture returns on their investment.

Length of retention is anticipated to correspond with a greater willingness to pay for superior genetics associated with carcass and feedlot performance attributes. This variable is defined by binned responses following growth stages in the traditional beef market as beef x dairy animals are ultimately destined for the retail beef market that is dominated by these marketing stages (Li & Cabrera, 2019a). Alternatively, the methods that these operations employ to market these beef x dairy animals are also considered. While anticipated to be correlated closely to retention length, marketing methods attempt to capture information concerning the probable destination of these beef x dairy calves. Calves destined for the cash market on a sale barn transaction are anticipated to represent a producers' focus on attributes that are phenotypically appealing at that stage. This would imply that these operators would likely focus on management type aspects such as calving ease over growth and performance attributes such as dry matter intake and marbling. Alternatively, marketing these same calves in a direct sale or retaining the calves through the finishing stage would likely incentivize producers to focus their efforts on growth and performance over management attributes in sire selection.

A final variable taken into consideration is knowledge of the expected progeny differences. Based on feedback from dairy operators who participated early in the data collection process (where several producers expressed poor familiarity with EPDs), knowledge of each of the non-price attributes was collected using a standard Likert scale. Details of this scale may be found in Table V of the results section.

Though this beef x dairy production survey does not furnish an exhaustive list of defining characteristics, we sought to better understand beef x dairy producers without adding further cognitive burden to the survey process. The beef x dairy production survey and a demonstration of the discrete choice experiment may be found in Appendix E.

### **3.4 Survey Distribution**

An electronic survey instrument given through the Qualtrics survey software system was used to gather information on dairy producers' preferences for genetic attributes. The initial subjects for this survey were identified through an online risk management survey of dairy producers in the top ten milk producing states as defined by the USDA. In that survey, respondents were asked if they would be interested in participating in this beef x dairy study. An electronic invitation to complete the survey was sent to those responding positively.

Additional distribution of the beef x dairy survey was accomplished in a multi-media approach consisting of an invitation through a leading publication company, direct contact with respondents from the risk management study, and direct contact achieved through an email list provided by DataAxle, Inc. We define these efforts further below.

The contact list afforded by the risk management study was utilized to contact dairy producers interested in taking a beef x dairy survey. Distribution of this survey to these direct contacts was accomplished following the Dillman methodology for electronic survey distribution, which is designed to reduce cognitive burden to the respondent (Dillman et al. 2014). A series of invitation emails were sent to the respondents with the opportunity available to participate in the survey, accomplished through a succession of invitations spaced a week apart with a brief explanation of the study contained in a cover letter. This letter highlighted the significance of beef genetic selection for dairy producers, aiming to emphasize the relevance of the study and thereby encourage participation. Producers were also informed of their rights as a participant and asked to provide consent before proceeding with the survey.

In addition to this direct approach afforded by the risk management survey, an email list furnished by DataAxle, Inc. as residual from the contact list provided to the risk management study was used to contact producers. Consisting of approximately 1500 dairy farmers, distribution was achieved in a series of two emails spaced a week apart, inviting producers to participate if they had not previously done so.

An advertisement distribution was given through the Farm Progress Journal in exchange for a brief overview of preliminary findings. The Farm Progress Journal, which represents a portfolio of producer-oriented publications including Feedstuffs, Feedstuffs365, BEEF, the National Hog Farmer, and Farm Progress provided access to a large population of farmers that may qualify to undertake the survey. Therefore, we utilized this publication to advertise the opportunity to participate in our survey collection efforts. This was done to inform producers of the legitimacy of the survey, while collecting responses outside the sample frame provided by the risk management survey. This effort was considered a minor success as approximately half of the gathered responses were collected from this source.

The entire survey distribution effort received 83 useable responses across all elicitation methods. The distribution methods and their details are shown below in Table II.

**Table II: Distribution Summary**

| <i><b>Distribution Method</b></i> | <i><b>Description:</b></i>                                                                               | <i><b>Date Released</b></i>                                                    | <i><b>Response Rate</b></i> |
|-----------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------|
| <i>Beef X Dairy Contact List</i>  | Direct Email Invitation to respondents of the dairy risk management survey who agreed to take BxD Survey | October 4, 2024<br>October 11, 2024*<br>October 18, 2024*<br>October 25, 2024* | 51.9%<br>40 Responses       |
|                                   | 1 <sup>st</sup> Round<br>- Sample Size: 84<br>- Bounced Emails: 6<br>- Failed Emails: 1                  |                                                                                |                             |
|                                   | 2 <sup>nd</sup> Round<br>- Sample Size: 9<br>- Bounced Emails: 0<br>- Failed Emails: 0                   | January 30, 2025<br>February 10, 2025*                                         | 55.6%<br>5 Responses        |
|                                   |                                                                                                          |                                                                                |                             |
| <i>Data Axle Contact List</i>     | Direct Email Invitation to RM contact list                                                               | October 25, 2024<br>November 6, 2024*                                          | 0.5%<br>7 Responses         |
|                                   | - Sample Size: 1459<br>- Bounced Emails: 17<br>- Failed Emails: 0                                        |                                                                                |                             |
| <i>Advertisements</i>             | Advertisement offered through Farm Progress News & State Association Contacts                            | September 25, 2024<br>October 30, 2024**                                       | N/A<br>38 Responses         |
|                                   | - Sample Size: Unknown                                                                                   |                                                                                |                             |

\*Reminder Email

\*\*Secondary Advertisement

### 3.5 Sample Size Requirements

There are multiple approaches described in the literature for determining the minimum sample size necessary to generate a set of reliable and accurate parameter estimates for a choice experiment. A primary driver in many cases is the need to maximize a sample subject to budgetary constraints, yet others use simple rules of thumb (e.g., Johnson & Orme, 2003, Pearmain et al. 1990, Lancsar & Louviere, 2008), or follow a parametric approach (e.g., de Bekker-Grob et al. 2015; Louviere, 2000, Rose & Bliemer, 2009). It is valuable to develop an

estimate of sample size requirements weighing anticipated costs and benefits to each method. While Pearmain et al. (1991) proposed that DCE designs require a minimum of 100 samples for preference data; Lancsar & Louviere, (2008) required only a sample size of 20 per questionnaire version for a reliable estimate. Utilizing the three blocks (i.e., questionnaire versions) required for the fractional factorial design developed within the methodology section, this places the minimum requirement at 60 respondents for this study. Alternatively, Johnson and Orme, (2003) illustrated the following rule of thumb to outline the following equation to set minimum sample size requirements:

$$n \geq \frac{500(C)}{t(a)} \quad (11)$$

Considering two-way interactions,  $c$  is equal to the largest number of levels set for all attributes under consideration (i.e., three for our study). Given the number of choice tasks ( $t = 9$ ) and available attributes ( $a = 4$ ) this method sets a minimum sample size of 56 observations. If necessary to reduce this requirement, we may follow Rose and Bliemer, (2013) who specified the possibility of reducing the number of respondents using larger block sizes or incorporating greater number of choice tasks. However, de Bekker-Grob et al. (2015) found that most studies contain 9 to 16 choice sets per respondent, placing this well within the grasp of the respondent.

The parametric approaches laid out by Louviere, (2000) and Rose and Bliemer, (2013) operate under distinct assumptions that are centered around the normality of the population. Louviere, (2000) estimated the required sample size as the following:

$$n \geq \frac{Z^2 * p * (1 - p)}{\epsilon^2 * t} \quad (12)$$

Following this method, minimal sample size  $n$  is a function of the product of the true population proportion  $p$  and the inverse cumulative normal distribution function  $Z$  over the product of the

allowed deviation from the normal distribution function  $\epsilon$  and the number of choice sets per respondent  $t$ . This method provides a population-based approach to determine sample size and requires an understanding of the true population prior to estimation. Alternatively, Rose and Bliemer, (2013) utilized prior parameter estimates from prior literature and a predetermined critical significant value to determine minimum sample size. This approach centers on measuring the precision of estimated parameters using D-efficiency scores to minimize the variance/covariance matrix of the parameter estimates offering a model tailored approach. Unfortunately, both are insufficient without either prior understanding of the population or parameter estimates which are secured from prior literature. Accordingly, we resort to the rules of thumb available within the literature to set a minimum sample size expectation of 60 samples.

## **Chapter 4 - Results**

### **4.1 Production Survey Results**

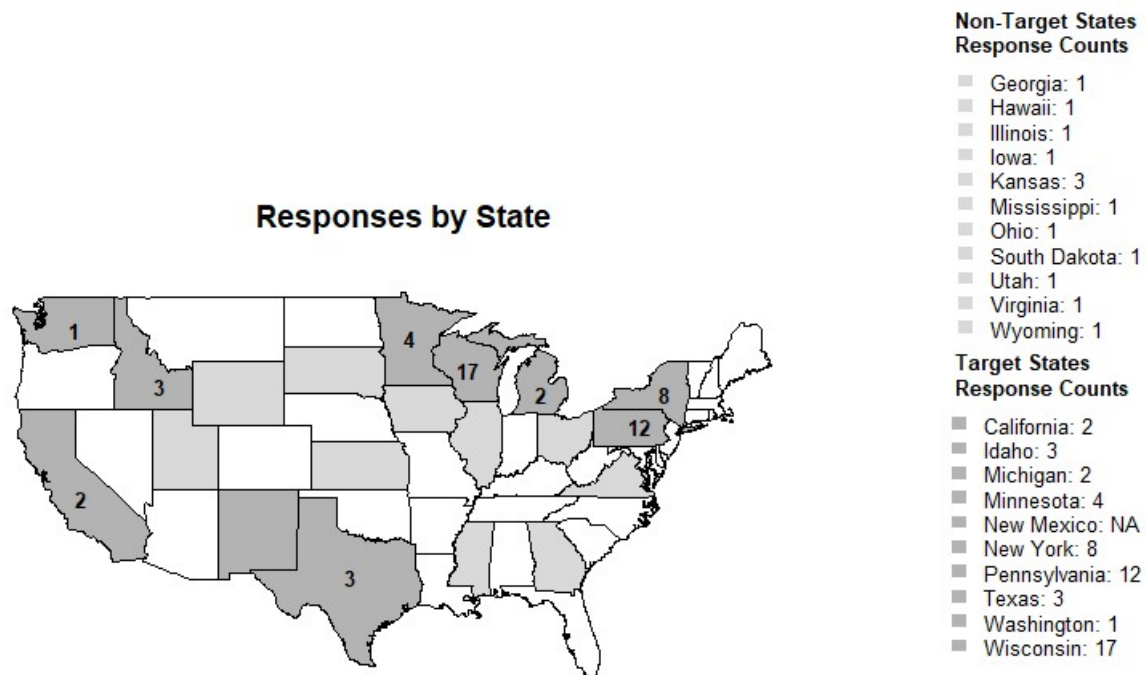
This study examined dairy producers' willingness to pay for beef genetic attributes in the form of EPDs using a discrete choice model. This was accomplished through the development of a survey instrument targeted towards dairy producers across the United States that incorporated key operator sociodemographic characteristics, operational characteristics, adoption motivations, and beef x dairy marketing information. We lay out the results of this survey beginning with the findings from the descriptive portion of our production survey before proceeding to the empirical portion of our study determining significance and willingness to pay estimates. We capture the results of the descriptive portion of our survey in Tables III, IV, and V.

A total of 104 surveys were collected through the distribution methods described in Table II of Chapter 3. Following data cleaning, 83 of these responses were deemed usable. These responses exceed the sample size requirements described by Lancsar & Louviere, (2008) and Johnson & Orme, (2003), as detailed in Chapter 3 Section 5. Participation in the discrete choice experiment provided over 144 observation points given that participants were presented with nine choice sets of four choices that each displayed four attributes. As participants were required to fully complete the discrete choice experiment section of the production survey to be considered, 1,908 total observations were yielded for consideration.

Data cleaning was accomplished in several steps beginning with the elimination of respondents who did not consent to be surveyed as well as those who did not fully participate in completing the discrete choice experiment portion of the producer survey. While incomplete responses were eliminated to avoid distortion of the results, they were still accounted for within

the summary statistics enabling us the opportunity to fully understand the reach of our surveyed sample relative to the population. Correlation between factors was evaluated to avoid multicollinearity within the results and to ensure that evaluated factors did not overlap, reducing the effectiveness of the results in conveying their message. That is, we do not have multiple factors that represent management desirable traits. (Lusk & Norwood, 2005) We include the results of this correlation in Appendix B.

**Figure 4-I: Collected Responses across the U.S. States**



Responses were collected from across the United States as a result of the distribution efforts outlined above. Though the risk management study that formed a cornerstone of these distribution efforts was targeted to the top ten milk producing states including California, Wisconsin, Idaho, New York, Texas, Michigan, Pennsylvania, Minnesota, New Mexico, and Washington, responses were also captured outside of the risk management study sample. This

carryover is likely a result of the Farm Progress Journal distribution effort which encompassed a national reach. As anticipated, less responses were collected from the Western portion of the U.S. Gillespie et al.'s (2024) examination of the structure of the U.S. dairy industry confirmed this tradeoff between number of farms and milk production in the Western region. Accordingly, response counts across the U.S. follow expectations. The distribution of responses by state across the continental U.S. are illustrated in Figure II.

**Table III: Summary Statistics of Dairy Operator Survey**

|                                                          | Responses | Percentage |
|----------------------------------------------------------|-----------|------------|
| <i>Operator Age:</i>                                     |           |            |
| 18-24                                                    | 6         | 7.59       |
| 25-34                                                    | 18        | 22.78      |
| 35-44                                                    | 14        | 17.72      |
| 45-54                                                    | 15        | 18.99      |
| 55-64                                                    | 16        | 20.25      |
| 65-74                                                    | 10        | 12.66      |
| 75 or older                                              | 0         | 0.00       |
| <i>Experience:</i>                                       |           |            |
| Less than 5 Years                                        | 3         | 4.69       |
| 5 to 10 Years                                            | 4         | 6.25       |
| 11 to 20 Years                                           | 4         | 6.25       |
| 21 to 30 Years                                           | 12        | 18.75      |
| 31 to 50 Years                                           | 12        | 18.75      |
| Greater than 50 Years                                    | 29        | 45.31      |
| <i>Education:</i>                                        |           |            |
| High School Diploma                                      | 15        | 22.73      |
| Associates or Technical Degree                           | 8         | 12.12      |
| 4 Year College Degree                                    | 38        | 57.58      |
| Advanced Degree                                          | 5         | 7.58       |
| <i>Operation Size:</i>                                   |           |            |
| Less than 50 Head                                        | 4         | 6.15       |
| 50 to 99 Head                                            | 9         | 13.85      |
| 100 to 199 Head                                          | 10        | 15.38      |
| 200 to 499 Head                                          | 10        | 15.38      |
| 500 to 999 Head                                          | 16        | 24.62      |
| 1000 to 1999 Head                                        | 8         | 12.31      |
| 2000 to 4999 Head                                        | 4         | 6.15       |
| 5000 to 9999 Head                                        | 3         | 4.62       |
| 10000 or more head                                       | 1         | 1.54       |
| <i>Beef x Dairy Adoption Motivation</i>                  |           |            |
| Improving Reproductive Performance                       | 23        | 10.80      |
| Exploiting Heterosis Benefits                            | 10        | 4.69       |
| Reduction in Global Dairy Demand for Replacement Heifers | 39        | 18.31      |
| Growing Use of Sexed Semen                               | 35        | 16.43      |
| Generation of Additional Cash Flow to Operation          | 59        | 27.70      |
| Increasing Acceptance to Beef on Dairy Animals           | 34        | 15.96      |
| Growing Availability of Superior Genetics                | 10        | 4.69       |
| Increasing Animal Welfare Concerns                       | 3         | 1.41       |

Based upon survey responses, the majority of producers are from 35 to 64 years of age (56.96%). The 2022 census of agriculture confirmed the representativeness of the sample by age as 61% of dairy operators were 35 to 64 years of age. Respondent experience was skewed towards greater than fifty years of experience aligning with expectations from the 2022 census which showed 80% of operators to have 11 or more years of experience. (USDA NASS, 2024) Alternatively, education is variable across operations with the majority of respondents reporting either a four-year degree or a high school degree. Regionally, this lies within expectations as operators in the Western region tend to have a higher percentage of operators holding a four-year college degree (Gillespie et al. 2024).

Operation size is demonstrated to be less representative of the U.S. dairy population. According to the 2022 census, approximately 45% of operations have an inventory greater than 2,500 head of cattle, while 29% account for operations between 100 to 999 head. (USDA NASS, 2024) This places our average surveyed operation significantly smaller with approximately 55.38% of operations with inventories between 100 to 999 head.

Survey responses revealed that producers are primarily motivated (27.70%) to undertake adoption of beef x dairy to generate additional cash flow. This aligns with expectations as business decisions are often motivated by profit maximizing behavior. Indeed, Pereira et al.'s (2022) survey of California dairy operators' motivations for incorporating beef x dairy cited extra profit as the main advantage of using beef semen. In addition to cash flow generation as a key motivator, several secondary motivations emerged. These include a reduction in demand for replacements heifers (18.31%), the growing availability of sexed semen (16.43%), increasing acceptance of beef x dairy calves (15.96%), and improving reproductive performance (10.80%) as top motivators for adoption according to survey results. Finally, less than 5% of operators are

motivated by exploiting heterosis benefits (4.69%), growing availability of superior genetics (4.69%), and increasing animal welfare concerns (1.41%). Taken in conjunction it appears that dairy producers are motivated primarily by embracing innovations in operational efficiency and profitability. These findings underline the importance of emphasizing economic drivers in shaping future beef x dairy adoption patterns.

**Table IV: Marketing Methods of Dairy Operator Survey Respondents**

|                                                    | Responses | Percentage |
|----------------------------------------------------|-----------|------------|
| <i>Growth Stage Calves Enter the Market</i>        |           |            |
| <i>Veal Calves (Birth Weight to 500 lbs)</i>       | 48        | 73.85      |
| <i>Stockers (500 to 600 lbs)</i>                   | 4         | 6.15       |
| <i>Feeders (700 to 900 lbs)</i>                    | 3         | 4.62       |
| <i>Live Cattle (900 lbs to Finish Weight)</i>      | 10        | 15.38      |
| <i>Beef x Dairy Marketing Methods</i>              |           |            |
| <i>Cash Market (Sale Barn Transaction)</i>         | 31        | 47.69      |
| <i>Direct Sale to “Calf Ranch” Operation</i>       | 18        | 29.69      |
| <i>Direct Sale to Beef Backgrounding Operation</i> | 3         | 4.62       |
| <i>Direct Sale to Feedlot Operation</i>            | 4         | 6.15       |
| <i>Retention through Finishing Stage</i>           | 9         | 13.85      |

Beef x dairy producers market their animals in a variety of ways. These results follow closely the weights at which these calves were sold with approximately 47% of respondents selling their calves through simple sale barn transactions, while an additional 25% of respondents sell their calves directly to backgrounding calf ranches. Alternatively, several producers indicated retaining beef x dairy calves to heavier weights, as 13% of the surveyed operations retain their beef x dairy calves through the finishing stage. This is remarkably in line with Sterry et al. (2023), who found 12.5% of surveyed producers were retaining their beef x dairy calves through the finishing stage, though the majority of beef x dairy calves were marketed in the early life stages.

Respondents’ knowledge of beef EPDs was also considered. Distributions reveal that survey respondents believed themselves to have basic knowledge of beef EPDs. However,

participants were less certain of their knowledge of specific EPDs. Operators are uncertain in their knowledge of calving ease and marbling EPDs though they appear to have greater confidence in their knowledge of the dry matter intake EPD.

**Table V: Dairy Operator EPD Knowledge Survey Respondents**

|                                            | No Knowledge | Minimal Knowledge | Basic Knowledge | Intermediate Knowledge | Advanced Knowledge |
|--------------------------------------------|--------------|-------------------|-----------------|------------------------|--------------------|
| <i>Expected Progeny Differences (EPDs)</i> | 6            | 13                | 20              | 9                      | 8                  |
| <i>Calving Ease Direct EPD</i>             | 7            | 21                | 16              | 12                     | 6                  |
| <i>Dry Matter Intake EPD</i>               | 6            | 9                 | 21              | 11                     | 9                  |
| <i>Marbling EPD</i>                        | 6            | 15                | 16              | 12                     | 7                  |

To summarize, the production survey provided valuable insights into beef x dairy producers including sociodemographic characteristics, adoption motivations, marketing methods, and knowledge of beef EPDs. Several key takeaways were revealed by the results of these efforts.

- 1) Beef x dairy producers are primarily motivated by the improvements afforded by beef x dairy as an innovation in operational efficiency and profitability.
- 2) Surveyed operators primarily sold their beef x dairy calves at the early stages of production, though a small percentage of operators retain their calves to the live cattle stage that exceeds 900 lbs.
- 3) The average surveyed dairy producer reported little familiarity with calving ease direct and marbling EPDs.

## 4.2 Conditional Logit Results

We estimated a conditional logit and random parameter model as outlined in Chapter 3 to determine significance and willingness to pay estimates. Results for the conditional logit and random parameters (mixed) are specified in Table VI and VII, respectively. McFadden pseudo  $R^2$  estimates (0.086) indicate that the conditional logit is a relatively poor fit though the model does explain some variability in choices. Results reveal the marginal effect of key attributes on the probability of an operator choosing a specific straw. In addition, marginal WTP effects are calculated for each non-price attribute. These results highlight the significance of inferior calving ease direct EPDs and high marbling EPDs in shaping a desirable product balanced against price.

**Table VI: Conditional Logit Regression Results**

|                                   | Marginal Effect <sup>1</sup><br>( $\sigma$ ) | Marginal WTP <sup>2</sup><br>( $\sigma$ ) | WTP Estimate <sup>3</sup> |
|-----------------------------------|----------------------------------------------|-------------------------------------------|---------------------------|
| Constant                          | 1.35*<br>(0.29)                              | -                                         | -                         |
| None                              | -6.63*<br>(0.79)                             | -                                         | -                         |
| Block1                            | 0.05<br>(0.15)                               | -                                         | -                         |
| Block 2                           | -0.10<br>(0.15)                              | -                                         | -                         |
| Price                             | -0.14*<br>(0.17)                             | -                                         | -                         |
| High Calving Ease Direct<br>(CED) | 0.13<br>(0.15)                               | 0.91<br>(1.05)                            | 15.91                     |
| Low Calving Ease Direct<br>(CED)  | -0.90*<br>(0.16)                             | -6.45<br>(1.37)                           | 9.55                      |
| High Dry Matter Intake<br>(DMI)   | -0.31****<br>(0.16)                          | -2.23<br>(1.15)                           | 12.77                     |
| Low Dry Matter Intake<br>(DMI)    | -0.01<br>(0.15)                              | -0.07<br>(1.08)                           | 14.93                     |
| High Marbling (MARB)              | 0.49**<br>(0.15)                             | 3.52<br>(1.16)                            | 18.52                     |
| Low Marbling (MARB)               | -0.16<br>(0.16)                              | -1.13<br>(1.13)                           | 13.87                     |
| Observations:                     | 1,908                                        |                                           |                           |
| McFadden Pseudo $R^2$             | 0.086                                        |                                           |                           |
| Log Likelihood                    | -803.6                                       |                                           |                           |

<sup>1</sup>Significant at p-values  $p < 0.000$  (\*),  $p < 0.001$  (\*\*),  $p < 0.01$  (\*\*\*), and  $p < 0.05$  (\*\*\*\*)

<sup>2</sup>WTP at the mean of the parameter distributions expressed in USD

<sup>3</sup>WTP estimate using \$15 as baseline price (USD)

Looking to the significance of the constant, the baseline marginal benefit of selecting an available option reflects the preference of producers to choose an option over none. This is further reflected in the significant disfavor given to the “None” alternative (-6.63). In addition, insignificant Block 1 and 2 marginal effect estimates indicate that producers do not demonstrate significant differences in their choice preferences based on the blocks employed to survey producer preferences. Accordingly, bias from the survey block design is demonstrated to be negligible.

As expected, straw price drives producers’ preferences with a significant negative influence that indicates an increase in price decreases the producer’s interest in purchasing. Dairy producers producing beef x dairy calves are therefore demonstrated to be price conscious in their beef genetic purchasing decisions. In addition to price, there is a significant negative coefficient for inferior calving ease of -0.90. As calving ease is diminished, the probability of a producer choosing the straw is diminished. This is indicative that producers are wary of forgoing calving ease benefits and any reductions in this EPD are significant in reducing utility to the producers. This is to be anticipated as both beef and dairy literature indicates that improvements in calving ease traits are significant in driving sire value. Ultimately, dairy producers are interested in producing a higher value animal but not at a cost to their primary milk production enterprise. As calving difficulties jeopardize this primary enterprise, inferior calving ease traits are unacceptable. Willingness to pay estimations also reflect producers’ preference towards avoiding calving ease EPD losses. Producers’ marginal willingness to pay is reduced by \$6.45 per straw purchased for calving ease traits that are inferior to the baseline 60<sup>th</sup> percentile of the American Angus Association’s EPD rankings.

Alternatively, the probability of a producer selecting a straw increases if the straw exhibits superior marbling traits. This is demonstrated in the positive significant coefficient of high marbling traits of 0.49. Given these findings, the marginal benefit afforded to superior marbling traits is indicative of producers' desire to advance the quality of their progeny utilizing the marbling trait as an improvement metric. Producers are willing to pay an additional \$3.52 per straw for straws exhibiting superior marbling EPD traits as opposed to baseline marbling EPDs.

Finally, the coefficient for the marginal effect of superior dry matter intake EPDs is negative and significant at -0.31. This is likely indicative of producers electing to focus on terminal and management type traits such as marbling and calving ease traits over production traits such as dry matter intake. Marginal willingness to pay estimates for superior dry matter intake EPDs are reduced by \$2.23 per straw. Given this estimation, producers are clearly less concerned about this EPD than inferior calving ease traits though more similar in impact of improvements in marbling EPDs. A likely explanation of this significance may be drawn from our surveyed understanding of beef x dairy producers. Based on these results, the majority of operators are marketing their calves early enough to be unconcerned about feeding performance traits.

In interpreting the willingness to pay (WTP) for non-price attributes, we discover that the marginal WTP estimates lie in the expected direction with both marbling and calving ease direct. Producers are willing to pay an additional \$3.52 for straws with superior marbling traits over the baseline, while producer WTP is reduced by \$6.45 for straws with inferior calving ease direct traits compared to the baseline. While perhaps diminutive at first glance, an operation that is purchasing 1000 straws annually (or more) is willing to take on a significant additional cost. Assuming the operation requires 1000 straws annually, operations of that size would be willing

to pay an additional \$3,520 for their entire straw portfolio for superior marbling traits.

Additionally, operations would pay \$6,450 less for their entire straw portfolio for inferior calving ease traits.

Notably, several attributes came up as insignificant in the multinomial logit regression. What these results reveal in terms of producer preferences is that producers are actively avoiding inferior calving ease and dry matter intake traits, while rewarding marbling traits producers. Key among these traits that go against expectations is superior calving ease traits. Based on prior literature, we would expect significant benefits to improvements in the calving ease direct EPD. However, while producers appear to be wary of declines in this trait, they are evidently comfortable with accepting the baseline calving ease direct EPD. Additionally, while producers are actively rewarding superior marbling traits, they are less concerned about purchasing straws with inferior marbling traits.

To summarize, dairy producers' preferences are towards improvements in marbling and calving ease EPDs and less towards improvements in dry matter intake. Producers demonstrate a marked decrease in WTP (\$-5.79) in instances of straws with inferior calving ease traits. Surprisingly, superior dry matter intake traits demonstrate decreases in WTP. Superior dry matter intake traits are subject to a \$2.09 discount in producer WTP.

### **4.3 Random Parameters (Mixed) Logit Results**

Taking the standard multinomial logit model a step further, we stipulated normality for the non-continuous variables following Schumacher et al. (2012) using a random parameters model. This model operates under the assumption that the population preferences follow a normal distribution across non-continuous attributes therefore relaxing the stipulation that preferences are homogenous across individuals. In this way, individual tastes and preferences are

allowed to vary across the population, thereby allowing for a more appropriate estimation of WTP.

This preference homogeneity may be tested based on the significance of the mean and standard deviation of each of the coefficients. The mean estimation indicates the direction and strength of the effect the attribute has on the probability a producer chooses the straw.

Alternatively, the standard deviation quantifies the magnitude of preference homogeneity or heterogeneity. A significant standard deviation is indicative of preference heterogeneity for the variable in question. More specifically, the standard deviation is found to significantly deviate from zero contrary to the null hypothesis implying variation in the effect of the attribute across respondents. Marginal WTP is calculated for each attribute. The results of the mixed logit regression are captured in Table VII.

**Table VII: Random Parameters (Mixed) Logit Regression Results**

|                                        | Mean Utility<br>Estimate <sup>1</sup><br>( $\sigma$ ) | Standard<br>Deviation<br>Estimate <sup>2</sup><br>( $\sigma$ ) | Marginal<br>WTP <sup>3</sup><br>( $\sigma$ ) | WTP<br>Estimate <sup>4</sup> |
|----------------------------------------|-------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------|------------------------------|
| Constant                               | 1.55*<br>(0.33)                                       |                                                                | -                                            | -                            |
| Block1                                 | 0.26<br>(0.24)                                        |                                                                | -                                            | -                            |
| Block 2                                | 0.07<br>(0.24)                                        |                                                                | -                                            | -                            |
| Price                                  | -0.16*<br>(0.02)                                      |                                                                | -                                            | -                            |
| None                                   | -9.39*<br>(1.73)                                      | 0.81<br>(2.23)                                                 | -                                            | -                            |
| High Calving Ease Direct<br>(High_CED) | 0.01<br>(0.22)                                        | 1.04*<br>(0.21)                                                | 0.08<br>(1.98)                               | 14.92                        |
| Low Calving Ease Direct<br>(Low_CED)   | -1.35*<br>(0.29)                                      | 1.31*<br>(0.30)                                                | -8.24<br>(1.98)                              | 6.76                         |
| High Dry Matter Intake<br>(High_DMI)   | -0.52***<br>(0.21)                                    | 0.74**<br>(0.23)                                               | -3.17<br>(1.31)                              | 11.93                        |
| Low Dry Matter Intake<br>(Low_DMI)     | 0.01<br>(0.22)                                        | 0.35<br>(0.29)                                                 | -0.09<br>(1.06)                              | 14.93                        |
| High Marbling<br>(High_MARB)           | 0.52***<br>(0.21)                                     | 0.87***<br>(0.24)                                              | 3.19<br>(1.34)                               | 18.40                        |
| Low Marbling<br>(Low_MARB)             | -0.12<br>(0.17)                                       | 0.00<br>(0.33)                                                 | -0.74<br>(1.06)                              | 14.29                        |
| Observations:                          | 1,908                                                 |                                                                |                                              |                              |
| McFadden Pseudo $R^2$                  | 0.123                                                 |                                                                |                                              |                              |
| Log Likelihood                         | -771.5                                                |                                                                |                                              |                              |

<sup>1,2</sup>Significant at p-values  $p < 0.000$  (\*),  $p < 0.001$  (\*\*), and  $p < 0.01$  (\*\*\*)

<sup>3</sup>WTP at the mean of the parameter distributions expressed in USD

<sup>4</sup>WTP estimate at the mean of the parameter distributions using \$15 as baseline price (USD)

The random parameters logit model estimation provides similar results to our prior estimation of the multinomial logit model. Model fit was improved in this estimate with a McFadden pseudo  $R^2$  of 0.123 indicating a relatively good fit. As before, RPL results indicate that producers prefer to make a choice over none. This is further emphasized by the significant negative coefficient of the “None” option that indicates producers strongly prefer making a choice over the “none of the above” option. As both block 1 and 2 coefficients are insignificant, we may presume that producers’ preferences are unaffected by the discrete choice survey block they were delegated to.

As shown before in the standard multinomial logit regression results, price is a significant factor for dairy producers’ beef genetics choice. Mean utility estimates provide similar results to the standard multinomial logit as producers are less likely to purchase straws with inferior calving ease (-1.35) and more likely to purchase straws with superior marbling traits (0.52). The significant status of the negative relationship of superior dry matter intake traits in shaping producers purchasing decisions is also confirmed. Examining standard deviations from this mean utility provides us with another story, significant standard deviations of superior and inferior calving ease direct traits as well as superior marbling traits demonstrates heterogeneity of producer preferences. This implies that producers are split in their preferences for these traits and substitute these traits in their purchasing decisions.

While significant, none of these standard deviation estimates are substantially far from zero implying that variation in preferences across individuals is not marked. This heterogeneity likely exists due to their unfamiliarity with EPDs as demonstrated by the surveyed subjective knowledge. In particular, general knowledge of EPDs appears to be skewed towards less

familiarity, while producers are more familiar with calving ease direct measures. Alternatively, dry matter intake and marbling measures are unfamiliar to producers.

Marginal WTP estimates provided through the RPL are consistent with those provided by the MNL estimation. While marginal differences in WTP estimates are revealed, these differences are of the magnitude of less than \$0.50. Producer WTP is reduced by \$8.24 per straw purchase for inferior calving ease and \$3.07 per straw purchase for superior dry matter intake. Alternatively, superior marbling traits drive improvements in producer WTP of \$3.19 per straw purchased.

#### **4.4 Market WTP Assessment**

A natural progression of the WTP estimates provided by our estimation of the random parameters' logit model is to better understand the market for beef EPDs through our sample. This is accomplished by plotting the distribution of individual's WTP for each attribute across the entire sample population. Given these distributions, it may be better understood what proportion of the surveyed population is willing to pay mean estimates versus those who are unwilling to pay more or less based on a standard deviation. We therefore plotted individual WTP distributions estimating quartiles to determine the proportion of the population that is willing to pay the specified values. Each quartile represents what percentage of the population is willing to pay. These quartiles are demonstrated below in Table VIII.

**Table VIII: Individual WTP Quartile Estimates**

|                                | Distribution Quartiles <sup>1</sup> (25% Increments) |                 |              |
|--------------------------------|------------------------------------------------------|-----------------|--------------|
|                                | Bottom Quartile                                      | Median Quartile | Top Quartile |
| High Calving Ease Direct (CED) | \$14.38                                              | \$15.25         | \$15.94      |
| Low Calving Ease Direct (CED)  | \$5.63                                               | \$6.80          | \$7.97       |
| High Dry Matter Intake (DMI)   | \$10.64                                              | \$11.87         | \$12.38      |
| Low Dry Matter Intake (DMI)    | \$14.62                                              | \$15.24         | \$16.15      |
| High Marbling (MARB)           | \$17.49                                              | \$18.24         | \$19.34      |
| Low Marbling (MARB)            | \$13.75                                              | \$14.41         | \$15.16      |

<sup>1</sup>WTP estimate at the mean of the parameter distributions using \$15 as baseline price (USD)

These quartile results based on individual WTP distributions demonstrate the variability of producer WTP across the sample population. Producers in the top quartile represent 25% of the surveyed population that has a WTP greater than the estimate provided for each attribute. Those in the median quartile represent an additional 25% of respondents who have a WTP greater than the provided estimate. Finally, the last quartile of respondents have a WTP greater than the bottom quartile estimate. For example, 25% of respondents are willing to pay more than \$15.94 for superior calving ease traits, 50% are willing to pay more than \$15.25, and 75% are willing to pay more than \$14.38 for this trait.

The clear loss in value from inferior calving ease traits is made more readily apparent in this quartile estimation, with the upper quartile of producers displaying a WTP of less than \$8 per straw. Given quartile segmentation, respondents may be targeted based on WTP. Specifically, seedstock producers may utilize a graduated pricing model to maximize their returns. For example, producers may market straws with superior marbling traits priced at \$19.34

to the top quartile of producers. The next quartile of the market may then be offered slightly lower value straws with less advantageous yet still superior marbling traits at a lower premium in order to capture the additional quarter of respondents who are willing to pay more than this amount. In doing so, these producers may maximize their returns displaying each of the attributes under consideration.

#### **4.5 Retention Segmentation**

We further expand our understanding of these unique producers by segmenting WTP results given retention practices. Given that approximately half of producers are selling their beef x dairy calves early in life and typically to a cash market (see Table IV), exploring producers' preferences across this marketing distinction is crucial. Those producers marketing through a sale barn are likely to have divergent objectives as they are not part of a direct feedback mechanism that is otherwise likely to exist, given marketing directly to a buyer or retention through the finishing stage. A key aspect of this hypothesis is that these producers will focus more on management characteristics over terminal and performance traits.

Producers were accordingly categorized into early marketing operations selling to a cash market (n= 31) and those retaining a more direct stake in the success of the resulting calves including those operations marketing directly to “calf ranches”, beef backgrounding operations, feedlot operations, or retaining calves through the finishing stage (n= 34). We will refer to these groups hereafter as cash marketers (B1) and direct marketers (B0). Conditional and random parameter logit results given this segmentation are illustrated below in Tables IX and X respectively.

**Table IX: Conditional Logit Regression Results split by cash marketing (B1) and direct marketing (B0) groups**

|                                | Marginal Effect <sup>1</sup><br>(σ) |                   | Marginal WTP <sup>2</sup><br>(σ) |                 |
|--------------------------------|-------------------------------------|-------------------|----------------------------------|-----------------|
|                                | B1                                  | B0                | B1                               | B0              |
| Constant                       | 1.75*<br>(0.46)                     | 1.09**<br>(0.41)  | -                                | -               |
| None                           | -8.26*<br>(1.39)                    | -5.51*<br>(1.02)  | -                                | -               |
| Block1                         | -0.10<br>(0.23)                     | 0.09<br>(0.23)    | -                                | -               |
| Block 2                        | -0.40<br>(0.25)                     | 0.07<br>(0.20)    | -                                | -               |
| Price                          | -0.14*<br>(0.02)                    | -0.13*<br>(0.02)  | -                                | -               |
| High Calving Ease Direct (CED) | 0.03<br>(0.21)                      | 0.23<br>(0.21)    | 0.21<br>(1.47)                   | 1.69<br>(1.48)  |
| Low Calving Ease Direct (CED)  | -0.92*<br>(0.24)                    | -0.92*<br>(0.23)  | -6.37<br>(1.92)                  | -6.63<br>(1.97) |
| High Dry Matter Intake (DMI)   | -0.63**<br>0.24                     | 0.04<br>(0.22)    | -4.39<br>(1.76)                  | 0.29<br>(1.56)  |
| Low Dry Matter Intake (DMI)    | 0.09<br>(0.21)                      | -0.07<br>(0.22)   | 0.66<br>(1.49)                   | -0.49<br>(1.56) |
| High Marbling (MARB)           | 0.45***<br>(0.22)                   | 0.49***<br>(0.21) | 3.10<br>(1.65)                   | 3.55<br>(1.62)  |
| Low Marbling (MARB)            | -0.28<br>(0.23)                     | -0.06<br>(0.22)   | -1.93<br>(1.60)                  | -0.44<br>(1.60) |
| Observations:                  | 900                                 | 972               |                                  |                 |
| McFadden Pseudo $R^2$          | 0.109                               | 0.081             |                                  |                 |
| Log Likelihood                 | -367.9                              | -412.5            |                                  |                 |

<sup>1,2</sup>Significant at p-values  $p < 0.000$  (\*),  $p < 0.001$  (\*\*), and  $p < 0.01$  (\*\*\*)

<sup>3</sup>WTP at the mean of the parameter distributions expressed in USD

**Table X: Random Parameters Logit Regression Results split by cash marketing (B1) and direct marketing (B0) groups**

|                                        | Mean Utility Estimate <sup>1</sup><br>( $\sigma$ ) |                  | Standard Deviation<br>Estimate <sup>2</sup><br>( $\sigma$ ) |                   | Marginal WTP <sup>3</sup><br>( $\sigma$ ) |                 |
|----------------------------------------|----------------------------------------------------|------------------|-------------------------------------------------------------|-------------------|-------------------------------------------|-----------------|
|                                        | B1                                                 | B0               | B1                                                          | B0                | B1                                        | B0              |
| Constant                               | 1.97*<br>(0.51)                                    | 1.27**<br>(0.45) |                                                             |                   | -                                         | -               |
| Block1                                 | 0.03<br>(0.35)                                     | 0.37<br>(0.34)   |                                                             |                   | -                                         | -               |
| Block 2                                | -0.27<br>(0.37)                                    | 0.24<br>(0.30)   |                                                             |                   | -                                         | -               |
| Price                                  | -0.16*<br>(0.03)                                   | -0.16*<br>(0.03) |                                                             |                   | -                                         | -               |
| None                                   | -10.63*<br>(1.74)                                  | -7.92*<br>(1.39) | 0.26<br>(2.36)                                              | 0.09<br>(1.77)    | -                                         | -               |
| High Calving Ease<br>Direct (High_CED) | -0.16<br>(0.35)                                    | 0.19<br>(0.30)   | 1.19*<br>(0.36)                                             | 0.93*<br>(0.28)   | -0.95<br>(2.10)                           | 1.13<br>(1.80)  |
| Low Calving Ease<br>Direct (Low_CED)   | -1.32*<br>(0.39)                                   | -1.48*<br>(0.43) | 1.23*<br>(0.35)                                             | 1.41*<br>(0.39)   | -8.02<br>(2.66)                           | -8.95<br>(2.92) |
| High Dry Matter<br>Intake (High_DMI)   | -0.85**<br>(0.26)                                  | -0.06<br>(0.30)  | 0.06<br>(0.72)                                              | 0.89**<br>(0.31)  | -5.14<br>(1.76)                           | -0.37<br>(1.82) |
| Low Dry Matter<br>Intake (Low_DMI)     | 0.11<br>(0.24)                                     | -0.05<br>(0.26)  | 0.17<br>(0.48)                                              | 0.44<br>(0.42)    | 0.70<br>(1.47)                            | -0.32<br>(1.56) |
| High Marbling<br>(High_MARB)           | 0.48<br>(0.32)                                     | 0.51<br>(0.29)   | 0.91***<br>(0.36)                                           | 0.80***<br>(0.32) | 2.94<br>(1.99)                            | 3.09<br>(1.81)  |
| Low Marbling<br>(Low_MARB)             | -0.28<br>(0.25)                                    | 0.01<br>(0.25)   | 0.02<br>(0.36)                                              | 0.15<br>(0.65)    | -1.70<br>(1.54)                           | 0.60<br>(1.49)  |
| Observations:                          | 900                                                | 972              |                                                             |                   |                                           |                 |
| McFadden<br>Pseudo $R^2$               | 0.151                                              | 0.116            |                                                             |                   |                                           |                 |
| Log Likelihood                         | -350.8                                             | -396.6           |                                                             |                   |                                           |                 |

<sup>1,2</sup>Significant at p-values  $p < 0.000$  (\*),  $p < 0.001$  (\*\*), and  $p < 0.01$  (\*\*\*)

<sup>3</sup>WTP at the mean of the parameter distributions expressed in USD

Comparison of the two retention groups provides some key insights into discrepancies in preferences. In both the conditional and random parameters logit, despite relying on less observations, the model fit is more appropriate for cash marketers' preferences (B1). This is seen in improvements in the McFadden pseudo  $R^2$  as well as the relative increases in log likelihood when moving from the B0 model to the B1 model.

The conditional logit model comparison reveals that, across both groups, reductions in calving ease traits drive significant reductions in marginal value. In addition, improvements in the marbling trait characteristics of a given straw significantly drive straw value ( $B1 = 0.45$ ,  $B0 = 0.49$ ). Alternatively, the loss of significance in the discount assigned to superior dry matter intake when moving from the cash group to the direct marketing group is suggestive of a greater acceptance to this beneficial trait. This is likely tied to greater acceptance for the need to be aware of improvements in performance as well as terminal and production type traits. A producer who is directly marketing their beef x dairy calves to a buyer is likely to be more receptive of traits that their buyers could benefit from. In addition, these producers are also likely to have a better understanding of the traits that impact performance beyond the development of low cost phenotypically sound calves.

The discrepancies revealed by the random parameters logit reveal more confidence in producers' choices across groups. Despite superior dry matter intake driving significant discounts for straws with this trait to the cash market group, the lack of significance in the standard deviation estimate is indicative of producers' preferences against improvements in dry matter intake. Producers from both the cash (B1) and direct marketing group (B0) still demonstrate heterogeneity in their preferences towards inferior calving ease traits implying that producers are less certain of their WTP for this trait. This is further reflected in the larger

standard deviations displayed by marginal WTP estimates for inferior calving ease across groups.

**Table XI: Individual WTP Quartile Estimates split by cash marketing (B1) and direct marketing (B0) groups**

|                                | Distribution Quartiles <sup>1</sup> (25% Increments) |         |                 |         |              |         |
|--------------------------------|------------------------------------------------------|---------|-----------------|---------|--------------|---------|
|                                | Bottom Quartile                                      |         | Median Quartile |         | Top Quartile |         |
|                                | B1                                                   | B0      | B1              | B0      | B1           | B0      |
| High Calving Ease Direct (CED) | \$12.32                                              | \$15.22 | \$13.35         | \$15.91 | \$14.75      | \$17.27 |
| Low Calving Ease Direct (CED)  | \$4.90                                               | \$5.16  | \$7.17          | \$6.96  | \$9.60       | \$8.44  |
| High Dry Matter Intake (DMI)   | \$8.05                                               | \$13.23 | \$9.40          | \$14.23 | \$10.86      | \$15.71 |
| Low Dry Matter Intake (DMI)    | \$14.88                                              | \$13.52 | \$15.32         | \$13.97 | \$16.99      | \$15.28 |
| High Marbling (MARB)           | \$15.16                                              | \$15.96 | \$17.48         | \$17.70 | \$18.92      | \$19.95 |
| Low Marbling (MARB)            | \$12.64                                              | \$14.26 | \$13.50         | \$15.11 | \$14.29      | \$15.97 |

<sup>1</sup>WTP estimate at the mean of the parameter distributions using \$15 as baseline price (USD)

Comparing quartile estimates across the cash (B1) and direct marketing group (B0) confirms the discrepancies in WTP across the quartiles particularly in superior dry matter intake traits. However, given the close similarities in WTP across these quartiles, these estimates may be utilized to fully tailor their pricing strategies on a straw-by-straw basis given their available attributes. For instance, seedstock producers may capture 25% of the market for superior dry matter intake traits at a price point of \$10.86 for the cash marketing group and \$15.71 for the direct marketing group. Alternatively, setting these prices at \$8.05 for the cash marketing group and \$13.23 for the direct marketing group will capture 75% of the market at these price points given superior dry matter intake traits.

## **Chapter 5 - Discussions and Conclusions**

The purpose of this study was to quantify dairy producers' willingness to pay for beef EPD attributes in the development of beef x dairy calves. A discrete choice experiment was conducted as part of a larger production survey designed to better understand beef x dairy production and marketing decisions. The experiment represented a hypothetical scenario for dairy producers purchasing beef genetics in a semen straw. Survey participants were given the option of three straws with differing cost and EPD attributes, along with a non-purchase alternative. Respondents were required to choose one of the four options for each scenario for a total of nine choice scenarios each. Attributes included price, calving ease direct EPD, marbling EPD, and dry matter intake EPD.

The findings of this study have implications for several key stakeholders including the dairy producer, beef x dairy backgrounder, and beef feedlot buyer. The key implications for this study are the significant discounts for inferior calving ease traits and the significant premium for superior marbling traits. Another key finding provided by this study is that superior DMI is significant in its negative effect on producer selection decisions. This is suggestive of producers focusing on terminal benefiting traits like marbling, which is a major driver of value in the market. In addition, calving ease traits are preferred over development traits such as dry matter intake. This result is consistent with the production survey results that demonstrate that the majority of producers sell their calves early, thus paying less attention to production factors that only indirectly impact their operations.

Comparing the final estimates afforded by our studies to the general straw market, we find that estimates lie within expectations. An examination of semen straw prices available on Bovine Elite demonstrates the typical straw price to range from \$25 to \$40 per straw for

registered angus genetics and approximately \$10 per straw for commercial angus genetics (Bovine Elite, n.d.). This would place the maximum willingness to pay provided by our calculations (\$18.52) at a substantially higher value than commercial straws. While this would place our estimates below the registered price, this is likely a result of setting prices based on averages found in commercially oriented studies. To address this, we rescaled the price range specification by a factor of three with prices set at \$30, \$45, and \$60 which better aligns with market values for registered straws. Accounting for this adjusted price range, interpretation of the WTP estimate can then be reassessed to \$55.56 for straws with a superior marbling trait. Comparison of the WTP estimates when considering both the commercial range and the seedstock range are demonstrated in Table XII. Overall, WTP estimates align with expectations, providing evidence for the reliability of the estimates as measures.

**Table XII: WTP Estimates subject to Commercial and Seedstock Valuation**

|                                     | Commercial Range<br>WTP Estimate <sup>1</sup><br>(~\$10) | Seedstock Range<br>WTP Estimate <sup>2</sup><br>(~\$25 to \$40) |
|-------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------|
| High Calving Ease Direct (High CED) | 15.91                                                    | 47.73                                                           |
| Low Calving Ease Direct (Low CED)   | 9.55                                                     | 25.65                                                           |
| High Dry Matter Intake (High DMI)   | 12.77                                                    | 38.31                                                           |
| Low Dry Matter Intake (Low DMI)     | 14.93                                                    | 44.79                                                           |
| High Marbling (High MARB)           | 18.52                                                    | 55.56                                                           |
| Low Marbling (Low MARB)             | 13.87                                                    | 41.61                                                           |

<sup>1</sup>WTP estimate at the mean of the parameter distributions using \$15 as baseline price (USD)

<sup>2</sup>WTP estimate at the mean of the parameter distributions using \$45 as baseline price (USD)

The results of this study benefit several key direct and indirect stakeholders. The most obvious and direct benefactors of this study are the dairy producers themselves. While perhaps not directly representative of their own preferences, these findings represent a proportion of the population. Accordingly, dairy producers are afforded a glimpse into their colleagues' preferences for beef attributes. This glimpse provides producers with a chance to reassess their selection priorities based on feedback provided by this study. For instance, an operator that is not actively discounting CED, as our results demonstrate, may reassess their decision making to consider calving traits more carefully.

In addition to dairy producers, the beef “seedstock” producers are another key direct benefactor of this study, developing and marketing their beef sires to markets including the beef x dairy market. These producers may improve their bottom line by focusing on the beef x dairy

market as a high value alternative to traditional beef producers. By focusing on those attributes that dairy producers are willing to pay a premium for these seedstock producers may tailor their sire and genetic sales to dairy producers.

Indirect benefactors of this study are the beef x dairy calf buyers and their customers. These indirect stakeholders are incentivized to improve the quality of the beef x dairy calves they select to collect top dollar bids. In particular, the beef feeding industry is eager for better information regarding beef x dairy growth performance and carcass merit (Schwab et al. 2024). To these consumers, this improved understanding drives returns. We leave it to future research to fully describe the benefits that this segment of the market will experience from such improved understanding of the genetics that dairy producers are employing in their development of the beef x dairy animal.

Ultimately, this study advances the understanding of dairy preferences for beef genetics. This information is valuable to stakeholders as a means of assisting price discovery in the market. Future research may be conducted to further define this market and the benefits of this improved understanding to the value chain.

A key limitation of this study is the total response rate. Though exceeding the minimum response rate as described by literature outlined in the sample size requirement section of Chapter 3, a larger sample size is a strong hedge against possible biases following the Law of Large Numbers. This law states that as the number of repeated observations increases, the sample mean converges to the population mean. (Blume & Royall, 2003) Accordingly, greater inferences may be drawn from a larger sample size than a limited one. For example, a greater number of responses would allow subsets of the data to be compared such as operations located in the Western and Eastern U.S. Fortunately, marginal effects estimates appear to be robust to

sample size as demonstrated by Bergtold et al. (2011) who found biases of the magnitude of less than one-thousandth for both large and small samples. Similar WTP studies have drawn conclusions from limited sample sizes with less than 200 responses. Notably, Schummacher et al. (2012) drew conclusions from 159 producer surveys while Vestal et al. (2013) utilized data from only 120 survey responses.

While it may be said that discrete choice modeling is the logical choice for developing an understanding of the marginal willingness to pay for individual attributes, there exist several limitations to this method. First and foremost, like any survey instrument, there exists a certain hypothetical nature associated with the choices made by an individual that are not subject to payment fulfillment. In other words, an individual will always be more willing to pay given they are not actually financially obligated to fulfill the terms of the agreement resulting in a positive bias in willingness to pay estimates for survey respondents.

While this methodology allows us to measure willingness to pay for certain key attributes, we are limited in the scope of our inquiry by the number of attributes under consideration. A standard hedonic model may take any number of factors under consideration. Alternatively, a discrete choice model is subject to a full factorial design that makes expansion beyond a given number of factors impractical if not impossible. As the length of a discrete choice model expands, responses are often called into question as the burden of response increases (Lusk & Norwood, 2005). Even after the application of a fractional factorial design which narrows the choices down to 27 alternatives, a three-block set up is needed to reduce the number of choice sets down to nine per individual, a hefty order for a single respondent.

Beyond the discrete choice methodology, the electronic survey instrument we chose has its own limitations. The primary concern of any survey designer lies in not reaching the subjects

of interest. An electronic survey may be cheaper and easier to place within reach of the average dairy producer (particularly if they indicate willingness to fill out the survey through another study). However, it may be entirely unavailable to a producer who is distrustful or unwilling to participate in an electronic survey. This unwillingness may originate from previous unpleasant experiences with phishing schemes, little capability of applying incentives to respondents, or little familiarity with the technology that an electronic medium relies on.

Every effort has been made to reduce the direct cognitive burden from this survey; however, there may yet exist some loss of interest or desire to complete the survey directly as a function of the length and complexity of the survey.

An additional limitation relates to the selection of the EPD's under consideration. While every effort has been made through the examination of previous literature to focus our study on those EPDs that are most relevant to dairy and beef producers' concerns, this process is not infallible. Dairy producers may, for instance, be actively selecting index traits such as \$Beef, \$Feedlot, etc. If correct, this study may provide little benefit to the producer. However, understanding WTP for an index would not have allowed us the opportunity to address the underlying factors that make up this index. An ideal study would consider all factors simultaneously, yet budgetary and temporal constraints which are addressed to some degree above restrict this as an opportunity.

Despite these limitations, the study should nevertheless be a useful reference to dairy and beef producers alike. The growth of the beef x dairy market has been well documented in this thesis. While many of the factors that have contributed to this growth are set and will continue to set the stage for beef x dairy producers across the U.S., one of the largest extraneous factors is the state of the U.S. beef herd. In periods of contraction, such as what we currently face, dairy

producers may compete with one another either through careful beef genetics selection or further investment in reproductive technologies that have lent efficiency to the process. The true test of this emerging industry will come as the beef industry corrects its inventory shortage by moving into a period of expansion that places the beef x dairy animal again at a disadvantage. It remains to be seen how producers who fail to compete in this marketplace ultimately perform in the future.

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## Appendix A - American Angus Association Fall 2024 Sire EPD Percentile Breakdown

| Top Pct | Production |       |       |       |          | Management |       |       |       |       |       |       |       |
|---------|------------|-------|-------|-------|----------|------------|-------|-------|-------|-------|-------|-------|-------|
|         | CED        | BW    | WW    | YW    | RAD<br>G | DMI        | YH    | SC    | Doc   | Claw  | Angle | PAP   | HS    |
| 1%      | +17        | -3.2  | +96   | +168  | +37      | -.72       | +1.4  | +2.26 | +35   | +.28  | +.31  | -2.50 | +.05  |
| 2%      | +16        | -2.6  | +92   | +162  | +35      | -.38       | +1.3  | +2.09 | +33   | +.31  | +.33  | -2.07 | +.11  |
| 3%      | +15        | -2.2  | +90   | +158  | +35      | -.21       | +1.2  | +1.98 | +32   | +.32  | +.35  | -1.80 | +.15  |
| 4%      | +15        | -1.9  | +88   | +155  | +34      | -.09       | +1.2  | +1.90 | +32   | +.34  | +.36  | -1.60 | +.18  |
| 5%      | +14        | -1.8  | +87   | +153  | +33      | -.01       | +1.1  | +1.82 | +31   | +.34  | +.37  | -1.42 | +.20  |
| 10%     | +13        | -1.0  | +82   | +144  | +32      | +.26       | +1.0  | +1.60 | +28   | +.38  | +.39  | -.84  | +.27  |
| 15%     | +11        | -.6   | +79   | +139  | +30      | +.42       | +.9   | +1.45 | +27   | +.40  | +.41  | -.43  | +.32  |
| 20%     | +11        | -.2   | +76   | +134  | +29      | +.55       | +.8   | +1.33 | +25   | +.42  | +.42  | -.13  | +.36  |
| 25%     | +10        | +.1   | +74   | +130  | +29      | +.66       | +.8   | +1.23 | +24   | +.43  | +.44  | +.14  | +.40  |
| 30%     | +9         | +.4   | +72   | +127  | +28      | +.75       | +.7   | +1.15 | +23   | +.45  | +.45  | +.38  | +.43  |
| 35%     | +8         | +.6   | +70   | +124  | +27      | +.83       | +.7   | +1.06 | +22   | +.46  | +.46  | +.59  | +.46  |
| 40%     | +8         | +.8   | +68   | +120  | +27      | +.91       | +.6   | +.99  | +21   | +.47  | +.47  | +.79  | +.48  |
| 45%     | +7         | +1.0  | +66   | +117  | +26      | +.99       | +.6   | +.92  | +20   | +.48  | +.47  | +.99  | +.50  |
| 50%     | +7         | +1.3  | +64   | +114  | +25      | +1.06      | +.5   | +.85  | +19   | +.49  | +.48  | +1.19 | +.53  |
| 55%     | +6         | +1.5  | +63   | +111  | +25      | +1.14      | +.5   | +.78  | +18   | +.50  | +.49  | +1.39 | +.56  |
| 60%     | +5         | +1.7  | +61   | +108  | +24      | +1.21      | +.5   | +.70  | +17   | +.51  | +.50  | +1.60 | +.58  |
| 65%     | +5         | +1.9  | +59   | +105  | +23      | +1.29      | +.4   | +.62  | +15   | +.53  | +.51  | +1.81 | +.61  |
| 70%     | +4         | +2.2  | +57   | +101  | +23      | +1.37      | +.3   | +.54  | +14   | +.54  | +.52  | +2.03 | +.64  |
| 75%     | +3         | +2.4  | +54   | +97   | +22      | +1.46      | +.3   | +.46  | +13   | +.55  | +.53  | +2.29 | +.67  |
| 80%     | +2         | +2.7  | +52   | +92   | +21      | +1.55      | +.2   | +.36  | +11   | +.57  | +.54  | +2.59 | +.71  |
| 85%     | +1         | +3.1  | +49   | +86   | +20      | +1.66      | +.1   | +.24  | +9    | +.59  | +.56  | +2.95 | +.75  |
| 90%     | +0         | +3.5  | +44   | +77   | +18      | +1.79      | +0    | +.09  | +7    | +.61  | +.57  | +3.41 | +.80  |
| 95%     | -2         | +4.2  | +35   | +62   | +16      | +1.99      | -.2   | -.13  | +3    | +.64  | +.60  | +4.15 | +.88  |
| Total   | 29,43      | 29,46 | 29,46 | 29,46 |          | 24,77      | 25,35 | 25,93 | 25,27 | 24,93 | 24,93 | 24,73 | 24,69 |
| Animals | 5          | 5     | 5     | 5     | 24,773   | 3          | 6     | 0     | 6     | 8     | 8     | 5     | 6     |
| Avg     | +6         | +1.3  | +63   | +112  | +.25     | +1.03      | +.5   | +.85  | +18   | +.49  | +.48  | +1.26 | +.54  |

| Top Pct       | Maternal |        |        |        |        |        | Carcass |        |        |        |
|---------------|----------|--------|--------|--------|--------|--------|---------|--------|--------|--------|
|               | HP       | CEM    | Milk   | MW     | MH     | \$EN   | CW      | Marb   | RE     | FAT    |
| 1%            | +19.9    | +17    | +40    | +139   | +1.4   | +25    | +86     | +1.61  | +1.34  | -.062  |
| 2%            | +18.9    | +16    | +39    | +130   | +1.3   | +22    | +82     | +1.47  | +1.25  | -.052  |
| 3%            | +18.3    | +15    | +38    | +124   | +1.2   | +20    | +79     | +1.38  | +1.20  | -.046  |
| 4%            | +17.9    | +15    | +37    | +120   | +1.1   | +19    | +77     | +1.31  | +1.16  | -.042  |
| 5%            | +17.5    | +15    | +36    | +116   | +1.1   | +17    | +75     | +1.26  | +1.13  | -.038  |
| 10%           | +16.1    | +13    | +34    | +105   | +.9    | +9     | +69     | +1.10  | +1.01  | -.026  |
| 15%           | +15.3    | +13    | +33    | +97    | +.8    | +3     | +66     | +.99   | +.93   | -.018  |
| 20%           | +14.6    | +12    | +31    | +90    | +.7    | -1     | +62     | +.90   | +.87   | -.011  |
| 25%           | +14.0    | +11    | +30    | +85    | +.7    | -4     | +60     | +.84   | +.82   | -.006  |
| 30%           | +13.5    | +11    | +29    | +80    | +.6    | -7     | +57     | +.78   | +.77   | +0     |
| 35%           | +13.0    | +10    | +29    | +75    | +.6    | -9     | +55     | +.72   | +.73   | +.004  |
| 40%           | +12.5    | +10    | +28    | +71    | +.5    | -11    | +53     | +.67   | +.69   | +.009  |
| 45%           | +12.1    | +9     | +27    | +67    | +.4    | -13    | +51     | +.62   | +.65   | +.013  |
| 50%           | +11.6    | +9     | +26    | +63    | +.4    | -16    | +49     | +.57   | +.61   | +.017  |
| 55%           | +11.2    | +8     | +26    | +59    | +.3    | -18    | +46     | +.52   | +.57   | +.021  |
| 60%           | +10.8    | +8     | +25    | +54    | +.3    | -20    | +44     | +.48   | +.53   | +.025  |
| 65%           | +10.3    | +7     | +24    | +50    | +.2    | -22    | +42     | +.43   | +.49   | +.030  |
| 70%           | +9.8     | +6     | +23    | +45    | +.2    | -24    | +39     | +.38   | +.44   | +.035  |
| 75%           | +9.3     | +6     | +22    | +39    | +.1    | -27    | +37     | +.33   | +.39   | +.040  |
| 80%           | +8.7     | +5     | +21    | +33    | +0     | -29    | +33     | +.28   | +.34   | +.045  |
| 85%           | +8.0     | +4     | +20    | +26    | -.1    | -33    | +30     | +.21   | +.27   | +.052  |
| 90%           | +7.1     | +3     | +19    | +16    | -.2    | -37    | +24     | +.14   | +.19   | +.061  |
| 95%           | +5.8     | +1     | +16    | -1     | -.5    | -42    | +15     | +.03   | +.08   | +.074  |
| Total Animals | 24,751   | 29,435 | 29,465 | 24,808 | 24,808 | 29,296 | 26,137  | 26,137 | 26,137 | 26,137 |
| Avg           | +11.6    | +8     | +26    | +61    | +.4    | -15    | +47     | +.60   | +.61   | +.017  |

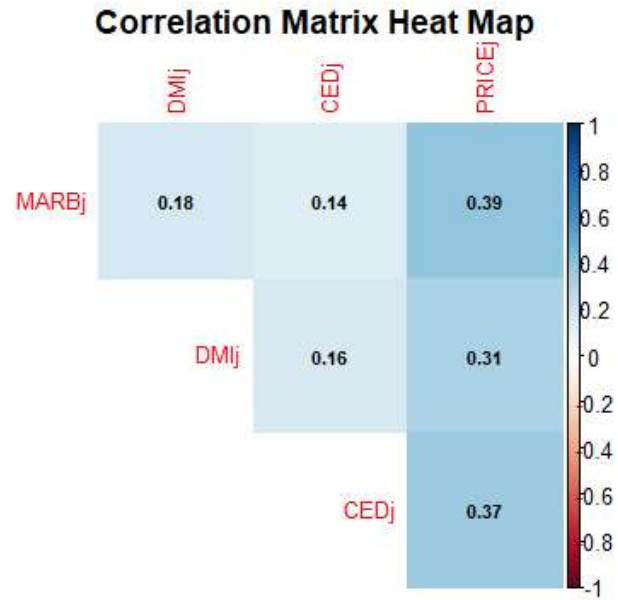
| Top Pct       | Angus-on-Dairy \$Values |        |        |        | \$Values |        |      |      |
|---------------|-------------------------|--------|--------|--------|----------|--------|------|------|
|               | \$AxH                   | \$AxJ  | \$M    | \$W    | \$F      | \$G    | \$B  | \$C  |
| 1%            | +234                    | +230   | +99    | +91    | +139     | +101   | +222 | +354 |
| 2%            | +219                    | +215   | +94    | +88    | +134     | +94    | +213 | +342 |
| 3%            | +208                    | +205   | +91    | +85    | +130     | +90    | +207 | +333 |
| 4%            | +201                    | +196   | +89    | +84    | +128     | +86    | +202 | +326 |
| 5%            | +194                    | +190   | +87    | +83    | +126     | +84    | +198 | +321 |
| 10%           | +173                    | +168   | +81    | +78    | +119     | +75    | +186 | +305 |
| 15%           | +158                    | +151   | +77    | +75    | +114     | +69    | +177 | +294 |
| 20%           | +147                    | +138   | +74    | +73    | +110     | +65    | +171 | +285 |
| 25%           | +137                    | +126   | +71    | +70    | +107     | +61    | +165 | +277 |
| 30%           | +128                    | +115   | +69    | +68    | +104     | +58    | +160 | +270 |
| 35%           | +119                    | +105   | +66    | +66    | +101     | +55    | +156 | +264 |
| 40%           | +111                    | +95    | +64    | +64    | +98      | +52    | +152 | +259 |
| 45%           | +102                    | +85    | +62    | +63    | +96      | +50    | +147 | +253 |
| 50%           | +94                     | +76    | +61    | +61    | +93      | +47    | +143 | +247 |
| 55%           | +85                     | +65    | +58    | +59    | +91      | +45    | +139 | +241 |
| 60%           | +75                     | +55    | +56    | +57    | +88      | +42    | +135 | +235 |
| 65%           | +66                     | +43    | +54    | +55    | +85      | +40    | +131 | +228 |
| 70%           | +54                     | +31    | +52    | +53    | +82      | +38    | +126 | +222 |
| 75%           | +42                     | +18    | +50    | +50    | +79      | +35    | +121 | +214 |
| 80%           | +26                     | +4     | +47    | +47    | +75      | +32    | +115 | +206 |
| 85%           | +8                      | -14    | +43    | +44    | +71      | +29    | +109 | +196 |
| 90%           | -16                     | -35    | +39    | +39    | +66      | +26    | +99  | +182 |
| 95%           | -52                     | -68    | +32    | +32    | +55      | +21    | +83  | +160 |
| Total Animals | 29,265                  | 29,473 | 29,266 | 27,562 | 27,532   | 27,524 |      |      |
| Avg           | +86                     | +70    | +60    | +59    | +92      | +49    | +143 | +244 |

**Explanation:**

The Fall 2024 percentile breakdown published by the American Angus Association is utilized to set price levels for each of our non-price attributes. Low, medium, and high levels are set based off the 95<sup>th</sup>, 60<sup>th</sup>, and 1<sup>st</sup> percentile respectively. An animal with an EPD in the 1<sup>st</sup> percentile is superior to 99% of the other animals within the organization.

## Appendix B - Attribute Correlation Matrix

Appendix Figure 1. Correlation between discrete choice attributes



## Appendix C - SASS Choice Fractional Factorial Main Effects Block

### Coding

```
proc plan ordered;
  factors price1=3 price2=3 price3=3
          CED1=3 CED2=3 CED3=3
          DMI1=3 DMI2=3 DMI3=3
          Marb1=3 Marb2=3 Marb3=3
  /noprint;
  output out=full;
  run;
  %mktruns(3 3 3 3 3 3 3 3 3 3 3 3)
proc optex data=full
coding=orth seed=22;

class Marb1 Marb2 Marb3 DMI1 DMI2 DMI3 CED1 CED2 CED3 price1 price2 price3;
model Marb1 Marb2 Marb3 DMI1 DMI2 DMI3 CED1 CED2 CED3 price1 price2 price3;

generate n=27 method=m_federov keep = 1;
blocks structure = (3)9 iter = 1 keep =1;
examine number=1 design;
output out = sub1;

output out=design10;
title 'proc print data=design10;';
proc print data=design10;
  run;
```

#### Explanation:

The above SASS coding provides the available optimal combinations given orthogonal and full-factorial designs for a discrete choice experiment. Having selected the design that is best suited to our problem, we apply blocks structure of three blocks with nine choice sets available. This code illustrates the available combinations yielding a 92.65% D-efficiency score which we deem acceptable given the scale of the problem.

**Saturated = 25**  
**Full Factorial = 531,441**

| Some Reasonable<br>Design Sizes | Violations | Cannot Be<br>Divided By |
|---------------------------------|------------|-------------------------|
| 27 *                            | 0          |                         |
| 36 *                            | 0          |                         |
| 45                              | 0          |                         |
| 54 *                            | 0          |                         |
| 30                              | 66         | 9                       |
| 33                              | 66         | 9                       |
| 39                              | 66         | 9                       |
| 42                              | 66         | 9                       |
| 48                              | 66         | 9                       |
| 51                              | 66         | 9                       |
| 25 S                            | 78         | 3 9                     |

\* - 100% Efficient design can be made with the MktEx macro.  
 S - Saturated Design - The smallest design that can be made.  
 Note that the saturated design is not one of the recommended designs for this problem. It is shown to provide some context for the recommended sizes.

The SAS System

| n  | Design                | Reference            |
|----|-----------------------|----------------------|
| 27 | 3 ** 13               | Fractional-Factorial |
| 36 | 2 ** 11 3 ** 12       | Orthogonal Array     |
| 36 | 2 ** 4 3 ** 13        | Orthogonal Array     |
| 36 | 2 ** 2 3 ** 12 6 ** 1 | Orthogonal Array     |
| 36 | 3 ** 13 4 ** 1        | Orthogonal Array     |
| 36 | 3 ** 12 12 ** 1       | Orthogonal Array     |
| 54 | 2 ** 1 3 ** 25        | Orthogonal Array     |
| 54 | 2 ** 1 3 ** 21 9 ** 1 | Orthogonal Array     |
| 54 | 3 ** 24 6 ** 1        | Orthogonal Array     |
| 54 | 3 ** 20 6 ** 1 9 ** 1 | Orthogonal Array     |
| 54 | 3 ** 18 18 ** 1       | Orthogonal Array     |

The OPTEx Procedure

| Class Level Information |        |        |   |   |
|-------------------------|--------|--------|---|---|
| Class                   | Levels | Values |   |   |
| Marb1                   | 3      | 1      | 2 | 3 |
| Marb2                   | 3      | 1      | 2 | 3 |
| Marb3                   | 3      | 1      | 2 | 3 |
| DMI1                    | 3      | 1      | 2 | 3 |
| DMI2                    | 3      | 1      | 2 | 3 |
| DMI3                    | 3      | 1      | 2 | 3 |
| CED1                    | 3      | 1      | 2 | 3 |
| CED2                    | 3      | 1      | 2 | 3 |
| CED3                    | 3      | 1      | 2 | 3 |
| price1                  | 3      | 1      | 2 | 3 |
| price2                  | 3      | 1      | 2 | 3 |
| price3                  | 3      | 1      | 2 | 3 |

---

|                |
|----------------|
| The SAS System |
|----------------|

| Design Number | D-Efficiency | The OPTEX Procedure |              |  | Average Prediction<br>Standard Error |
|---------------|--------------|---------------------|--------------|--|--------------------------------------|
|               |              | A-Efficiency        | G-Efficiency |  |                                      |
| 1             | 92.6479      | 85.3925             | 72.4538      |  | 1.0413                               |

---

## Appendix D - Choice Set Blocking Output

|                |
|----------------|
| The SAS System |
|----------------|

The OPTEX Procedure

| Design Number | Treatment    | Treatment    |
|---------------|--------------|--------------|
|               | D-Efficiency | A-Efficiency |

|   |         |         |
|---|---------|---------|
| 1 | 88.3774 | 80.1964 |
|---|---------|---------|

|                                           |            |
|-------------------------------------------|------------|
| Log determinant of the information matrix | 7.6135E+01 |
|-------------------------------------------|------------|

|                                  |            |
|----------------------------------|------------|
| Average variance of coefficients | 4.6183E-02 |
|----------------------------------|------------|

|              |         |
|--------------|---------|
| D-Efficiency | 88.3774 |
|--------------|---------|

|              |         |
|--------------|---------|
| A-Efficiency | 80.1964 |
|--------------|---------|

| POINT<br>NUMBER | BLOCK<br>NUMBER | MARB1 | MARB2 | MARB3 | DMI1 | DMI2 | DMI3 | CED1 | CED2 | CED3 | PRICE1 | PRICE2 | PRICE3 |
|-----------------|-----------------|-------|-------|-------|------|------|------|------|------|------|--------|--------|--------|
| 1               | 1               | 1     | 2     | 1     | 3    | 3    | 2    | 3    | 2    | 2    | 1      | 2      | 3      |
| 2               | 1               | 3     | 1     | 1     | 2    | 1    | 1    | 2    | 3    | 2    | 1      | 1      | 3      |
| 3               | 1               | 2     | 1     | 2     | 1    | 2    | 1    | 3    | 2    | 3    | 1      | 3      | 3      |
| 4               | 1               | 1     | 3     | 2     | 3    | 3    | 1    | 2    | 2    | 3    | 2      | 1      | 1      |
| 5               | 1               | 3     | 2     | 1     | 1    | 3    | 3    | 2    | 3    | 3    | 2      | 3      | 3      |
| 6               | 1               | 3     | 3     | 2     | 2    | 3    | 2    | 1    | 1    | 1    | 1      | 3      | 2      |
| 7               | 1               | 2     | 2     | 1     | 1    | 1    | 2    | 1    | 2    | 3    | 3      | 1      | 2      |
| 8               | 1               | 1     | 1     | 2     | 1    | 2    | 3    | 3    | 3    | 1    | 3      | 1      | 2      |
| 9               | 1               | 2     | 2     | 3     | 2    | 2    | 1    | 2    | 1    | 1    | 2      | 2      | 1      |
| 10              | 2               | 1     | 1     | 1     | 1    | 2    | 2    | 2    | 1    | 2    | 2      | 3      | 1      |
| 11              | 2               | 2     | 3     | 3     | 3    | 2    | 2    | 2    | 3    | 3    | 1      | 2      | 2      |
| 12              | 2               | 3     | 1     | 1     | 3    | 2    | 1    | 1    | 2    | 1    | 2      | 2      | 2      |
| 13              | 2               | 3     | 2     | 3     | 1    | 3    | 1    | 3    | 1    | 2    | 3      | 1      | 2      |
| 14              | 2               | 1     | 3     | 1     | 2    | 2    | 3    | 1    | 1    | 3    | 3      | 2      | 3      |
| 15              | 2               | 2     | 1     | 3     | 3    | 3    | 3    | 1    | 1    | 1    | 1      | 1      | 3      |
| 16              | 2               | 1     | 2     | 3     | 2    | 1    | 3    | 3    | 3    | 1    | 1      | 3      | 1      |
| 17              | 2               | 2     | 3     | 2     | 1    | 1    | 2    | 1    | 3    | 2    | 2      | 2      | 3      |
| 18              | 2               | 2     | 1     | 2     | 2    | 3    | 3    | 2    | 2    | 2    | 3      | 2      | 2      |
| 19              | 3               | 1     | 1     | 3     | 2    | 3    | 1    | 1    | 3    | 3    | 2      | 3      | 2      |
| 20              | 3               | 3     | 2     | 2     | 2    | 2    | 2    | 3    | 2    | 1    | 2      | 1      | 3      |
| 21              | 3               | 2     | 3     | 1     | 3    | 1    | 3    | 3    | 1    | 2    | 2      | 3      | 2      |
| 22              | 3               | 2     | 3     | 1     | 1    | 3    | 1    | 3    | 3    | 1    | 3      | 2      | 1      |
| 23              | 3               | 2     | 2     | 2     | 3    | 2    | 1    | 1    | 3    | 2    | 3      | 3      | 1      |
| 24              | 3               | 3     | 1     | 2     | 3    | 1    | 2    | 3    | 1    | 3    | 3      | 2      | 1      |
| 25              | 3               | 3     | 3     | 3     | 1    | 2    | 3    | 1    | 2    | 2    | 1      | 2      | 1      |
| 26              | 3               | 1     | 2     | 2     | 1    | 1    | 1    | 2    | 1    | 1    | 1      | 2      | 2      |
| 27              | 3               | 1     | 3     | 3     | 3    | 1    | 2    | 2    | 2    | 1    | 3      | 3      | 3      |

### Explanation:

The SASS coding for blocking gives the above result. Given 27 available choice sets and the stipulation of three blocks, each block provides nine choice sets to each respondent giving the choice set combination for Straw A, B, and C. For example, the first choice set code for Option Straw A is a medium Marbling, low DMI, low CED straw choice offered at a price of \$15.

Utilizing this coding, we have the capability of setting levels for each of the choice sets to maximize the marginal impact of incorporating the choice sets available to us.

## Appendix E - Beef X Dairy Production Survey



### Beef X Dairy Genetic Selection



Dear <<First Name>>,

Would you consider taking our survey on Beef x Dairy genetic selection in dairy operations? Considering the growing role of beef-on-dairy cross cattle within the dairy industry we are asking for your assistance in our study examining the role of EPDs on beef bull selection. Our primary interest in this survey is in you as an operator and your motivations behind adopting beef on dairy cross cattle as well as your preferences for beef semen straws given a variety of select beef genetic attributes associated with a range of prices. While this research may not provide any direct benefit to you, this study may help guide outreach and education efforts.

This survey should take less than five minutes to complete and should place you at no great risk or discomfort. Your participation is entirely **voluntary** and you can withdraw from the research at any time. Additionally, your participation and responses in this survey will be kept entirely confidential. For concerns or to gain further information about your rights as a participant, you may contact the University Research Compliance Office at 785-532-3224 or fax at 785-532-3278 or by email at: [comply@k-state.edu](mailto:comply@k-state.edu).

Your input is extremely valuable to us, and we look forward to your participation in this project. The findings from this survey will be available to you if requested. If you have any questions, feel free to contact us using the contact information below.

By proceeding with the survey, you are giving informed consent to the above conditions.

Sincerely,

**Aaron Johnson**

Kansas State University

Associate Professor

Agricultural Economics

[ajjohnson@ksu.edu](mailto:ajjohnson@ksu.edu)

**Calder McCollum**

Kansas State University

Graduate Research Assistant

Agricultural Economics

[calderm@ksu.edu](mailto:calderm@ksu.edu)

## SECTION 1: BACKGROUND

1. Please provide the following background information about yourself.
  - a. What state is your operation located in? \_\_\_\_\_
  - b. Age \_\_\_\_\_ (years)
  - c. What is the highest level of formal education that you have received?
    - ☐ High School Diploma
    - ☐ Some College
    - ☐ 4 Year College Degree
    - ☐ Advanced Degree
  - d. Do you produce beef x dairy calves on your operation? [Qualifier Question]
    - ☐ Yes
    - ☐ No

---

## SECTION 2: FARM CHARACTERISTICS

2. How many head of dairy cattle does your operation have on-site (milking age cows)?  
(Please select the best option below.)
  - ☐ Less than 50 Head
  - ☐ 50 to 100 Head
  - ☐ 100 to 200 Head
  - ☐ 200 to 500 Head
  - ☐ 500 to 1,000 Head
  - ☐ 1,000 to 2,000 Head
  - ☐ 2,000 to 5,000 Head
  - ☐ Greater than 10,000 Head
3. How long has milk been produced by your operation?  
(Please select the best option below.)
  - ☐ Less than 10 Years
  - ☐ 10 to 20 Years
  - ☐ 21 to 30 Years
  - ☐ 31 to 50 Years
  - ☐ Greater than 50 Years

---

## SECTION 3: MOTIVATION AND MARKETING

2. Please select all that best describe your reasons for adopting beef x dairy genetics on your operation.  
(Please select all that apply)
  - ☐ Improving Reproductive Performance
  - ☐ Exploiting Heterosis Benefits
  - ☐ Reduction in Global Dairy Demand for Replacement Heifers
  - ☐ Growing Use of Sexed Semen
  - ☐ Generation of Additional Cash Flow to an Operation
  - ☐ Increasing Acceptance of Beef on Dairy Animals within the Cash Market
  - ☐ Growing Availability of Superior Genetics

☐ Increasing Animal Welfare Concerns

3. At what stage of production do you typically market the calves that you produce from a beef x dairy cross?

*(Please select the best option below)*

- ☐ Veal Calves (Birth Weight to 500 lbs)
- ☐ Stockers (500 to 600 lbs)
- ☐ Feeders (700 to 900 lbs)
- ☐ Live Cattle (900 lbs to Finish Weight)

4. What market methods do you utilize to sell your beef x dairy cross cattle?

*(Please select all that apply)*

- ☐ Cash Market (Sale Barn Transaction)
- ☐ Direct Sale to “Calf Ranch” Operation
- ☐ Direct Sale to Beef Backgrounding Operation
- ☐ Direct Sale to Feedlot Operation
- ☐ Retention through Finishing Stage

5. Compared to the average dairy producer, how would you describe your knowledge of the following:

|                                            | No Knowledge          | Minimal Knowledge     | Basic Knowledge       | Intermediate Knowledge | Advanced Knowledge    |
|--------------------------------------------|-----------------------|-----------------------|-----------------------|------------------------|-----------------------|
| <i>Expected Progeny Differences (EPDs)</i> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> |
| <i>Calving Ease Direct EPD</i>             | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> |
| <i>Dry Matter Intake EPD</i>               | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> |
| <i>Marbling EPD</i>                        | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/>  | <input type="radio"/> |

#### SECTION 4: CHOICE EXPERIMENT

Please consider the following choice sets below. The purpose of this experiment is to ascertain your preference as a dairy producer for beef genetic attributes given select prices and available attributes. Given the choice sets available to you below, please select the choice [Straw A, B, or C] that most closely reflects your preference for **each** choice set.

Please consider the following choices. Assume that you are purchasing Angus genetics from a reputable seller to cross with a dairy dam to produce beef x dairy calves and the three options are identical in every other aspect.

*(Please select the semen straw that you would purchase given price and the EPD attributes given.)*

|                            | Straw A                  | Straw B                  | Straw C                  | If these were the only options available, I would buy something else. |
|----------------------------|--------------------------|--------------------------|--------------------------|-----------------------------------------------------------------------|
| <i>Price (\$/Straw)</i>    | \$15                     | \$20                     | \$10                     |                                                                       |
| <i>Calving Ease Direct</i> | +17                      | +5                       | +17                      |                                                                       |
| <i>Dry Matter Intake</i>   | -0.71                    | -0.71                    | -0.71                    |                                                                       |
| <i>Marbling</i>            | +1.56                    | +1.56                    | +1.56                    |                                                                       |
|                            | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |                                                                       |

#### **Explanation:**

We include a portion of the beef x dairy survey as a reference to survey design and structure. Nine choice sets are presented to each respondent which are required to be fully completed to complete the survey.