The Power of Economic Selection Indices to Make Genetic Change in Profitability

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Introduction

The Beef Improvement Federation defines selection as "Choosing some individuals and rejecting others as parents of the next generation of offspring" (Beef Improvement Federation, 2016). This is a very simple, but accurate, way to describe one of the most important things we do in the cattle industry. Through selection, we have the power to control the flow of genetics that will ultimately determine the beef herd of the future. Cattlemen have historically used the best information available at the time to make genetic improvements to their herds. Granted, the train has fallen off the tracks a few times, but those same or improved selection tools were there to get us back on track. We contend that one of the best tools available for selection today, selection indices, is being underutilized.

Historically, selection was first practiced based on visual appearance and adaptation to local environments, which ultimately led to the development of breeds. This remained the basis of selection for many years until early in the twentieth century when the concept of heritability was applied to livestock species and expanded selection to some production traits based on actual or adjusted measurements. From the 1930's through the 1980's cattlemen used the knowledge of heritability to change cattle, sometimes in drastic ways from the extremely short, blocky cattle of the 1950's to the extremely large framed cattle of the 1980's. Single trait selection seemed to be the norm and took the cattle industry on some wild pendulum rides. National Cattle Evaluations and the publishing of Expected Progeny Differences (EPDs) started in the 1970's. They received widespread adoption and became the selection tool of choice throughout the 80's and 90's providing cattlemen with a more dependable means of making genetic change. For the first time cattlemen were able to make their decisions based on estimates of genetic merit across herds and years. In the mid 2000's, DNA/molecular technology was developed and its initial release caused a level of confusion for cattlemen because it was presented as a competing technology with EPDS. Eventually, methodologies were developed to permit incorporation of the molecular data into NCE with the result being EPDs with greater accuracies.

Expected Progeny Differences incorporating molecular technology, has given us an extremely powerful tool to make genetic change for a wide array of production traits. An EPD has not been developed for every economically important trait, but the list is expanding and every area of production has at least minimal EPD representation. Even though EPDs give cattlemen a great tool for making genetic change in production traits, they ignore economic considerations. It has been up to the individual cattleman to determine the economic impact of each trait and try to formulate that information into a multi-trait selection scheme. Without an organized, systematic approach to this complicated endeavor, the results are likely less than desirable. Unfortunately, this has led to an overemphasis on selection for increased outputs

without due consideration to the traits affecting costs. It is important to remember that income does not equal profitability; PROFITABILITY = INCOME – COSTS. The solution to this was the development of economic selection indices, which many breed associations and some private companies have developed and published starting in 2004. This technology was developed in 1940s (Hazel, 1943), and has been used extensively in other livestock industries, but has not seen widespread use in beef until recently. In Weaber's (2014) summary he stated "Selection indices provide a single value, usually reported in dollars, for the selection of breeding stock that optimizes selection on a number of traits the define profit in a particular production scenario. Selection indexes simplify selection by weighting EPDs by appropriate economic values to estimate the net merit of a selection candidate under a predefined breeding objective or goal". The Beef Improvement Federation has presented information on the development and advancement of this technology (Crews, 2005; Spangler, 2010, Brigham, 2011; Ochsner, 2016); however, the purpose of this paper is to address increased adoption.

Why Selection Indices?

In order to make wise selection decisions cattlemen are encouraged to define breeding objectives based on their management and market. Factors such as when and how the cattle will be marketed, retention of replacement heifers, feed quality, availability and cost, and other management practices all play a role in determining breeding objectives. Breeding objectives give cattlemen a target to shoot for with their selection program.

Economic selection indices are a means of making selection decisions based on the economic impact of several traits simultaneously and make genetic progress towards increased profitability. In some cases, it allows for the selection of animals based on a single number that reflects the genetic contribution to its offspring's economic potential. In the best-case scenario, all of the EPDs of economic importance to the specific management and marketing scheme are included in the index. If profitability is the goal in the beef industry, then the authors argue that economic selection indices are the best selection tool available to achieve this end.

What is Available?

Many breeds and some private genetic evaluation companies are currently computing and publishing selection indices. These indices sort into three basic groups; Terminal (Table 1), Weaning/Replacement (Table 2) and All Purpose (Table 3).

Terminal Index

In general, these indices focus on a marketing endpoint of selling carcasses on a Quality and Yield Grade basis. The assumption is that no replacement females will be retained from this mating. Typically, these indices assume that primarily mature cows will be mated and therefore do not place much, if any, emphasis on calving ease. An important component of profitability in a terminal index is feed intake in relation to gain (feed efficiency). There is increasing information available on feed intake, but this trait is still unavailable for several of the indices.

Target: These indices are typically used to select bulls for commercial use when all calves are planned to be marketed as finished cattle or carcasses. No replacement females will be kept. Little to no emphasis is placed on calving ease, so awareness of the Calving Ease Direct EPD is advised, particularly if heifers are to be bred.

Weaning/Replacement Index

For many commercial cattlemen, weaning or yearling is when their cattle are marketed. In addition, a high percentage of these producers keep their own replacement heifers. Currently, few indices are designed to specifically fit this production scheme even though it represents the largest segment of the beef industry. Some All-Purpose indices may meet this need, particularly if the index places a strong emphasis on reproduction traits. If that is the case, then commercial cow/calf producers could effectively use the all-purpose index to effectively select bulls that would satisfy their cost/revenue streams while placing some emphasis on feedlot and carcass traits that will benefit the industry.

Target: These indices are for cow/calf cattleman that sell weaned or backgrounded calves and keep replacement heifers. Calving ease is considered in these indices, but if a large portion of the females to be mated are heifers then additional attention to calving ease may be warranted.

All-Purpose Index

The all-purpose indices assume a marketing endpoint of selling carcasses; however, with this index the management scheme assumes that replacement females will be retained. The indices have varying levels of emphasis on calving ease, but all include both Calving Ease Direct and Calving Ease Maternal. All indices include some measure of female fertility and carcass merit. Feed efficiency or feed intake are absent in most of the indices. Since the all-purpose indices include the entire production system, and include the greatest number of traits, the risk is spread out making these indices the most stable and robust.

Target: These indices take into consideration the entire production model from conception to carcass. These indices work best for cattlemen that plan to market steers and the majority of heifers as carcasses, but plan to retain replacement females from the mating. Seedstock producers that are targeting balance in their breeding program also use these indices.

Keys to Successful Implementation

The first key to successfully implementing an effective breeding program utilizing selection indices is to develop and define your breeding objectives. Selection causes change to the herd; most are intentional, but some are consequences. It is critical to know what traits are important to your management and marketing scheme, but also how selection for those traits affects other traits of economic importance. For example, if a selection scheme was implemented to maximize calf weaning weights and replacements are to be retained, it might be tempting to select for maximum weaning weight direct and weaning weight milk EPDs. The result of this system would be large weaned calves, but there may be other consequences. Because of genetic

correlations, this mating scheme would also result in large, heavy milking cows that require greater nutritional demands; if those demands are not met then reproductive failure is a likely result. When these traits are included in a selection index then proper economic weighting is placed on these traits to balance the costs and returns to maximize profit. When used properly, selection indices allow you to focus on your target while minimizing negative consequences based on a profitability model.

Selection indices do a great job of economically balancing the traits that are included in the index, but there may be traits of economic/convenience/quality of life value to your cattle business that are not in the index of choice. When this occurs, you need to use the index in tandem with the additional trait(s) of importance. A good example would be selecting for improved temperament in conjunction with improved carcass traits. In this scenario, it would be beneficial to select based on a combination of the Terminal Index and the Docility EPD. Another example would be a seedstock producer that wants to market bulls with large scrotal circumferences, with the expectation of improved bull fertility (Rusk, et. al, 2002), and desirable hair shedding ability in addition to good index values, a combined selection scheme would need to be implemented.

Most selection indices assume that traits have a linear relationship with profitability, which is not always the case. Calving Ease Direct is a good example; there is a certain level of calving ease that when reached no more incidences of dystocia will occur. At this point, increases in Calving Ease Direct EPD will not add to increased profitability of the bull, but larger values will continue to increase the index value. This will give the appearance of greater profitability than will be realized. Another trait that may not function in a linear manner is milking ability. Indices do account for the fact that milk contributes to both increased costs and increased revenue and balances the effects. However, at extreme values the consequences may not be reflected in a linear model. Extreme milk levels in a herd with limited resources may have devastating consequences in reproduction, and thus profitability, that the model cannot account for. From a practical standpoint, it makes sense to look at the individual EPD values of bulls that are being considered and avoid those with extreme values in traits of concern.

Some common reasons that cattlemen do not use selection indices is that they may not perfectly fit the management and marketing plan or they are concerned that prices change so the index being used for selection today may be different in the future. Within reason, these issues should have little impact on the genetic progress made by using selection indices (VandePitte and Hazel, 1977). As long as there is a value line for most or all of the traits in the index then the bulls that rise to the top will likely be the same bulls under slightly different circumstances.

What Does the Future Hold?

Selection Indices are a great tool, but there is still room for improvement. Some of the issues that need to be addressed are:

- Limited number of Economically Relevant Traits (ERT) for some areas that play a large role in profitability
- Limited indices specifically targeted to commercial cow/calf producers

- Gathering accurate commercial herd data in proper contemporary groups can enhance the accuracy of traits like stayability relative to commercial cow/calf selection
- Multi-breed indices that can incorporate heterosis information
- Accuracy values for indices similar to BIF accuracies for EPDs

Many of these concerns can be eliminated with minimal additional inputs, but others will require considerable work.

Work is currently underway to enhance the suite of ERTs in areas such as health, reproduction and feed efficiency/cow maintenance. All of these traits have significant impact on profitability, but EPDs in these areas are still limited. DNA/molecular technology will assist in improving the availability and accuracy of many of these traits, but large quantities of phenotypic data are still needed to make this happen.

Expanding the indices that would benefit commercial cow/calf producers that do not retain ownership should be extremely easy. Indices that have a marketing endpoint of weaning or after backgrounding and retained heifers would be of great benefit to a large segment of the beef industry and would require minimal resources. More information is needed on the effectiveness of using an all-purpose index in this segment of the industry. If it can be shown that genetic progress toward increased profitability is not significantly diminished, with the added benefit of improve feedlot and carcass performance, then this would be a great alternative that is also beneficial to the entire beef industry.

Developing selection indices that are multi-breed, with heterosis incorporated, are not impossible tasks, but will require considerable effort to implement. The USDA Meat Animal Research Center is our greatest resource for estimating heterosis values and have provided them for many traits; however, there are still gaps for some economically important traits. Work continues to develop heterosis values for the more difficult traits that influence profitability and when available it will facilitate the development of multi-breed indices.

Accuracy values associated with EPDs are a risk management tool; cattlemen know that lower accuracies means increased risk for a larger change in the genetic merit estimate of the animal. Unfortunately, there is not an accuracy value associated with selection indices at this time and thus no measure of risk associated with them.

As demand for selection indices increases, there will likely be an expansion in the number computed and improvements in their effectiveness. Part of this improvement will come in the increased accuracy in computing EPDs with molecular information. Additional improvements will come as new ERTs are developed and improved. The good news is that a tool that is very useful today will be even better in the future.

Conclusion

Selection indices provide cattlemen with a simple, effective tool to make multi-trait selection decisions that are profit driven. It is prudent to know what traits are included in a prospective index to ensure that individual management and marketing needs are being met and that undue influence is not coming from a trait that does not have a cost/revenue stream. Traits of importance that are not included in the index, heterosis considerations, convenience/personal preference traits, visual appraisal and other factors specific to your cattle business must remain a

part of your overall breeding program, but a well-matched selection index will aid in simplifying the selection process.

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Table 1: Traits included in Terminal Index based on published indices. Terminal – Feedlot and/or Carcass/No Replacements

	Trait								
Index	**CED**	**BW**	**WW**	**YW**	**Intake**	**PWG**	**CW**	**Quality**	**Yield**
Angus									
$Feedlot			X	X	X				
$Grid							X	X[j]	X[o,p]
$Beef			X	X	X		X	X[j]	X[o,p]
Beefmaster									
Terminal			X	X				X[k]	X[p]
Charolais									
Terminal Sire Profitability		X	X	X			X	X[j]	X[o,p]
Gelbvieh									
FPI	X		X		X	X	X	X[j]	X[m]
EPI				X	X	X			
Hereford									
Certified Hereford Beef[1]	X		X	X			X	X[k]	X[o,p]
Limousin									
Mainstream Terminal			X	X			X	X[j]	X[o,p]
Red Angus									
GridMaster			X	X			X	X[j]	X[o,p]
Simmental									
Terminal	X		X		X	X	X	X[j]	X[m]
Shorthorn									
Feedlot	X		X	X			X	X[j]	X[o,p]
Industry Indices									
Method QPI						X	X	X[j]	X[p]

CED = Calving Ease Direct, BW = Birth Weight, WW = Weaning Weight Direct, YW = Yearling Weight, PWG = Post-weaning Gain (see below), FE = CW = Hot Carcass Weight, Quality = Carcass Quality (see below), Yield = Carcass Yield (see below)

Quality = Marbling[j], Intramuscular Fat[k]

Yield = Yield Grade[m], Fat[o], Ribeye Area[p]

[1]Dry Matter Intake with be included starting summer 2017

Table 2: Traits included in Weaning/Replacement Index based on published indices. Feeder – Replacements/No Feedlot/No Carcass

	Trait								
Index	**CED**	**BW**	**CEM**	**WW**	**YW**	**Milk**	**HP**	**SC**	**Mat**
Angus									
$Wean		X		X		X			X
Beefmaster									
Maternal				X	X	X		X	
Shorthorn									
$CEZ	X				X				
Industry									
Method MPI	X		X	X		X	X		X

CED = Calving Ease Direct, BW = Birth Weight, CEM = Calving Ease Maternal, WW = Weaning Weight Direct, YW = Yearling Weight, Milk = Weaning Weight Maternal, HP = Heifer Pregnancy, SC = Scrotal Circumference, Mat = Mature Cow Size

Table 3: Traits included in All Purpose Index based on published indices. All Purpose – Replacement/Feedlot/Carcass

	Trait										
Index	**CED**	**CEM**	**WW**	**Milk**	**Fert**	**PWG**	**FE**	**Mat**	**CW**	**Qual**	**Yield**
Gelbvieh											
$Cow	X	X	X	X	X[a,b]	X[h]	X	X		X[j]	X[m]
Hereford											
Baldy Maternal[1]	X	X	X	X	X[c]	X[g]			X	X[k]	X[p]
Calving Ease[1]	X	X	X		X[c]				X	X[k]	X[p]
Brahman Influince[1]	X	X	X		X[c]				X	X[k]	X[p]
Red Angus											
HerdBuilder	X	X	X	X	X[a,b]	X[g]			X	X[j]	X[m]
Simmental											
All Purpose	X	X	X	X	X[a]	X[h]	X	X	X	X[j]	X[m]
Shorthorn											
$BMI	X	X	X	X		X[g]			X	X[j]	X[o,p]
Industry Indices											
Method ROI	X	X	X		X[b]	X[h]		X	X	X[j]	X[p]
Dollar Profit	X	X	X	X	X[d]	X[g]	X	X	X	X[j]	X[n,p]

CED = Calving Ease Direct, CEM = Calving Ease Maternal, WW = Weaning Weight Direct, Milk = Weaning Weight Maternal, Fert = Fertility (see below), PWG = Post-weaning Gain (see below), FE = Feedlot Feed Efficiency, Mat = Mature Cow Size, CW = Hot Carcass Weight, Qual = Carcass Quality (see below), Yield = Carcass Yield (see below)

Fertility = Stayability[a], Heifer Pregnancy[b], Scrotal Circumference[c], Days to Conception[d]

Post Weaning Gain = Yearling Weight[g], Feedlot Gain[h]

Quality = Marbling[j], Intramuscular Fat[k]

Yield = Yield Grade[m], % Retail Product[n], Fat[o], Ribeye Area[p]

[1]Dry Matter Intake, Sustained Cow Fertility and Heifer Calving Rate will be included starting summer 2017

Investing in the Future: Heifer Development for Longevity

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Selection and development of replacement heifers has, rightfully so, garnered considerable attention in research, educational programming, and popular press for many years. While the basic concepts have not changed for decades, new technologies, changes in market dynamics, and leveraging improved genetics has enabled producers to become more efficient with the dollars and time they invest in replacements.

Options for Procuring Replacement Heifers

There are three basic options for obtaining bred replacement heifers. The most common, but not necessarily the best, method is to retain heifers from each calf crop to develop and breed on-farm. Selling all the heifers in a calf crop and purchasing bred replacements or open heifers to breed is another option. The third option, and seemingly least used in beef cattle production, is to retain heifers from the calf crop and have them custom developed by someone else. Nuances develop in these three basic methods depending on geographical and individual farm/ranch influences. Several factors that impact this decision include economics, available resources, experience, genetic improvement, and convenience. The financial concerns of developing replacement heifers are related to diverting cash flow and resources. Consider purchasing replacements if higher returns can be generated by an alternative use for the proceeds from feeder calf sales.

Farm or ranch resources will also direct this decision. If forage or feed supplies are already maximized or overextended by the mature cow herd, then purchasing replacement heifers would be an obvious choice. Proper development of heifers takes a certain amount of knowledge and experience that differs from management of a mature cow herd. Opportunity costs are often overlooked when making management decisions. The convenience of having someone else raise replacements is a valid consideration, especially when the cattle operation is not the primary source of income or operator time or labor is limiting. Custom heifer development centers have become a support-business of the cow-calf sector. Consigning heifers to a custom developer is the best way to retain herd genetics while not using limited environmental resources from the cow herd to raise heifers.

Timeline and Objectives

The period of time most often indicated by the term “heifer development” is from weaning to confirmed pregnant after the first breeding season. For this discussion, that term refers to the period of time from weaning until confirmed pregnant as a two-year-old after the second breeding season. There are several factors that influence development and longevity prior to birth and between birth and weaning. Those factors are usually accounted for during selection or result in early culling during development.

In addition to the significant cash cost for retaining/purchasing and developing heifers, there is a tremendous amount of opportunity cost and time invested. Consider the time from a mating that