EVALUATING THE ECONOMIC VALUE OF PRODUCTS DERIVED FROM ADVANCED REPRODUCTIVE TECHNIQUES

Prepared by:

Michael McCarthy BVMS, Dip. Ag. Econs

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Declaration

I declare that this dissertation is solely my own work. Any work completed by others is clearly referenced within the dissertation.

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I would like to acknowledge the guidance and support of the postgraduate co-ordination team, as well as my supervisor associate Professor John House.

Abstract

This research project encompasses four papers that evaluate the economic value of products derived from advanced breeding techniques. These papers are presented under the following headings:

PART A – Calculating the Economic Value of Genetic Gain using an investment analysis approach.

PART B – Calculating the Economic Benefit of using Sex-Sorted Semen.

PART C – Calculating the Economic Benefit of using Embryos derived from MOET, JIVET and other In Vitro production (IVP) techniques.

PART D - The Modern Breeding Decision: New Dilemmas for the Australian Dairy Farmer.

The first paper develops a method of evaluating the economic value of genetic gain using an investment analysis approach. This provides the basis by which products with different anticipated fertility rates can subsequently be compared and also allows gender selection to be factored (including the value of additional sales). The second paper explores the benefits of using sex-sorted semen using the method developed in the first paper. The third paper explores the economic value of more advanced products (i.e. embryos derived from MOET, JIVET and/or harvested from slaughterhouses). This paper also explores a part-herd approach that identifies two breeding enterprises within the herd. The first is breeding heifers as herd replacements and the second is breeding heifers for sale. This recognizes that there is no opportunity to use “own performance” as a selection indicator and that selection is pre-determined by the genetic merit of the dam. It also recognizes that dams of lower genetic merit can be used as recipients for embryos thereby displacing dams from one enterprise to another. The final paper develops the approach to enable the evaluation of an individual mating, and highlights some of the dilemmas facing the modern dairy farmer.

PART A

CALCULATING THE ECONOMIC VALUE OF GENETIC GAIN USING AN INVESTMENT ANALYSIS APPROACH

Abstract

This paper develops a method to calculate the economic value of genetic gain using an investment analysis approach. The investment analysis approach allows products derived from advanced breeding products to be subsequently compared in the papers. In contrast to conventional semen, these products have inherently different anticipated fertility rates and many products may be select gender. Reduced fertility has a major influence on the cost of achieving genetic gain and gender selection affects the number of possible sales generated from a herd. The investment analysis approach enables both gender selection and different fertility to be factored into the calculations.

This paper demonstrates the method by comparing two scenarios. The default scenario attempts to mirror the parameters assumed by the industry gross margin model that is used to determine economic values for the industry traits. This scenario represents a steady state without any investment into genetic gain. The second scenario assumes some investment into genetic gain and a slightly different set of parameters. This paper does not attempt to compare products with differing fertility or gender selection. It is designed to "set the scene" for later papers and spells out the method in some detail. The investment analysis approach factors the costs and benefits over time and provides the ability to include additional sales. The reason for adopting this method will become more apparent in the subsequent papers.

The method developed in this paper builds on existing methodology that utilizes economic values, in conjunction with breeding values to provide farmers with a meaningful way of comparing bulls and choosing conventional semen.

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Introduction

The use of economic values is well suited to comparing bulls in a relative sense and provides dairy farmers with an excellent tool to make decisions about bull and semen selection (ADHIS publication 2012; ABS 2010; Pryce, J. E., J. H. van der werf, M. Haile-Mariam, B. Malcolm and M.E. Goddard 2010). It also provides valuable information about replacement females. Economic values can also be used to determine the economic value of genetic gain. Simplistically the value of genetic gain is the anticipated genetic change per trait, multiplied by the economic value of the trait, summed over all traits (pers. comm. Julius van der Werf).

The use of economic values alone, however, does not factor the way in which a genetic contribution might be made over the lifetime of a cow (Mulder 2001; Haile-Mariam, Bowman and Goddard 2010a, b) nor does it address the time involved before the benefit of the genetic gain is realized. The economic value reflects a steady state and describes the value of genetic gain once a steady state has been reached. As such it reflects the destination rather than the journey.

Economic values are determined using a simple industry gross margin model (van Arendonk 1985; Schneeberger et al. 1992; Bekman and van Arendonk 1993; Pearson and Miller 1981; Olynk and Wolf 2009; Groen, A. F. 1988; Dekkers and Gibson J.P. 2009b, a). This examines the effect of a single incremental unit change for each of these traits and determines how this affects the overall gross margin. This becomes the economic value of that trait. To determine these values, the model assumes a fixed (representative) fertility rate and fixed number and value of sales. An approach based simply on economic values, however, is unable to compare products with different anticipated fertility and/or the ability to choose gender.

An investment analysis approach builds on the economic values (weights) determined by the industry gross margin model and converts them into a cash flow. The cash flow (in terms of both income streams and costs) is examined over time and future income streams are discounted using an appropriate discount rate. The economic value is then expressed as a Net Present Value (NPV). This provides a meaningful way of calculating the absolute value of genetic gain. It also factors the additional cost associated with low fertility and the benefits of having more female replacements to sell. It can be used to assess the commercial application of new products such as sexed semen and embryos generated from JIVET, MOET as well as embryos harvested from cows at slaughter.

Background

The Australian dairy industry, through the auspices of the Australian Dairy Herd Improvement Service (ADHIS) evaluates over 35 traits. In general they are categorized as either production traits or as fitness traits. Milk volume, protein and fat are examples of production traits. Structural soundness, udder conformation and temperament are examples of fitness traits.

The Australian Dairy Industry utilizes two indices in its national breeding objective. The first is the Australian Selection Index (ASI) that has a focus on production (milk volume, fat and protein). The second is the Australian Profit Ranking (APR) that also includes other important traits such as longevity, fertility, milking speed, mastitis, temperament and live weight (ADHIS publication 2010b).

The economic values (weights) for the traits within the APR are determined using an economic model that reflects current prices and production parameters that are representative of a contemporary Australian dairy farm. The derivation of the economic values (weights), and the workings of the APR index is described technical manual describing the APR index (Pryce, J. E., van der Werf J., Haile-Mariam M, Malcolm W., Goddard M. 2010). The economic values derived by the model are used in conjunction with breeding values to rank the genetic merit of animals within the APR (ADHIS publication 2010c). These economic values and the APR formula are regularly updated (ADHIS publication 2010a; Pryce, J. E., J.

H. van der werf, M. Haile-Mariam, B. Malcolm and M.E. Goddard 2010). ADHIS provides a web-based tool to assist farmers to select utilize the APR to meet their breeding objective (ADHIS 2012).

Whilst production is generally foremost in the minds of those managing a breeding program, it is generally recognized that selection for milk production needs to be balanced against the costs arising from infertility, premature culling and managing bigger cows (Groen, Ab F. et al. 1997). Farmers are keen to select away from unacceptable temperament and slow milking speed. Resistance to mastitis is also considered important. This APR index was introduced in 2001 to incorporate these additional traits. The APR therefore includes the following traits (weighted by their appropriate economic values) (ADHIS publication 2010c, a):

APR = ASI + SURV + FERT + SCC + LWT + MS + TEMP

Where:

ASI - is the Australian Selection Index incorporating milk volume (expressed as litres), protein yield (expressed as kg) and fat yield (expressed as kg).

SURV – is survival and represent a measure of longevity. This factors key structural and conformation traits that are likely to become reasons for animals being culled from the herd (expressed as a percentage).

FERT – is daughter fertility and represents the likelihood of becoming pregnant (it is also expressed as a percentage).

SCC – is the somatic cell count reflecting the animal's resistance to mastitis (expressed as %)

LWT – is live weight and reflects the size of the animal and factors the additional maintenance cost associated with larger animals (expressed as kg).

MS – is milking speed (expressed on a scale of 1-5).

TEMP – is temperament as reflects the additional value of maintaining tractable cattle within the herd (expressed on a scale of 1-5).

The most recent economic weights (updated in April 2010 (ADHIS publication 2010c, a; Pryce, J. E., J. H. van der werf, M. Haile-Mariam, B. Malcolm and M.E. Goddard 2010)) are shown in Table 1. Note that the components of ASI (milk yield, protein yield and fat yield) are listed separately.

The major influence on achieving genetic gain, particularly at a herd level, within any particular trait relates to its heritability and the phenotypic variance of the trait within the population. Traits with high heritability have a greater potential for genetic gain (Simm 1998). Traits that exhibit a large variation (phenotypic or genetic variance) also have a greater potential for genetic gain.

Table 1. Showing the most recent economic values (weights) for the traits included in the APR (December 2010) (ADHIS publication 2010a, c).

Trait	Economic Value
ASI - Milk volume (litres)	$-0.084 AUD
ASI - Protein yield (kg)	$7.096 AUD
ASI - Fat yield (kg)	$1.434 AUD
SURV – Survival (%)	$6.988 AUD
FERT – Fertility (%)	$4.380 AUD
SCC – Mastitis Resistance (%)	$0.666 AUD
LWT – Liveweight (kg)	$-2.71 AUD
MS – Milking speed (1-5)	$1.627 AUD
TEMP – Temperament (1-5)	$4.276 AUD

** Source – ADHIS publication – Introducing APR 2010.*

Both heritability and an estimate of phenotypic variation are inherent in the breeding values determined for each of the animals in the breeding program. Otherwise the anticipated gain can be calculated at a herd level using the formula:

$$\textbf{(1)} \qquad \textbf{Response (per annum)} = \mathbf{h^2S/L}$$

(Simm 1998 (Simm 1998))

Where S is the selection differential, h^2 is the heritability and L – is the generation interval.

The calculation of the selection differential requires knowledge of both the standard deviation of the trait in question as well as the selection intensity applied to the herd replacements. Response is generally expressed as a percentage per year. This approach is well suited to the use of bulls or multiple mating that characterize production systems in other industries although the response for each trait must be calculated separately. It is less useful in the dairy industry, which is characterized by individual mating and the extensive use of artificial insemination.

A better way to calculated anticipated genetic gain, particularly when focusing on individual mating, is to use the simpler approach:

$$\textbf{(2)} \qquad \mathbf{PBV = \tfrac{1}{2}\,(ABV\ dam + ABV\ sire)}$$

(Simm 1998 (Simm 1998))

Where PBV is the predicted breeding value and ABV is the Australian Breeding Value.

The task is simplified even more if we utilize the industry APR index. This reduces the number of calculations required. It is well suited for use at the level of the individual mating. The formula then reads as follows:

$$\textbf{(3)} \qquad \mathbf{\$Profit_{progeny} = \tfrac{1}{2}\,(\$Profit_{dam} + \$Profit_{sire})}$$

Where \$Profit represents the value determined by the APR index.

The $Profit function reflects both the breeding values of the animals involved and economic value (weight) for each trait within the index. It factors the traits that are considered to be most important to profit. The economic value of the genetic gain is then the difference between the $Profit of the progeny and the average of the dams that make up the herd. The use of the $Profit function is an elegant and practical application of the industry's investment in performance recording and the production of animal breeding values. The method described in this paper builds on this platform.

Method

From the point of view of investment analysis, traits need to be categorized in a manner that reflects the timing of when they are expressed. Each trait expresses their value in a slightly different way at a different time. For example, whereby additional milk production may be evident at the point at which a heifer replacement enters the milking herd, a trait such as longevity may not be seen until the end of a cow's milking life. Fertility may be evident before the cow enters the milking herd. Furthermore, some traits will be make their contribution fairly evenly over the lifetime of a cow, whereas others such as calving ease may contribute unevenly (i.e. early in the life of the cow).

If we first take the 'early' traits (fertility, temperament & live weight) we can see that these traits will be evident prior to the replacement heifer entering the herd and be evident throughout the productive life of the cow. This benefit will be passed on to their progeny and again seen early in the life of this next generation (see Table 2).

Table 2. Shows NPV of traits that become evident prior to the replacement entering the milking herd (fertility, live weight & temperament).

		Year											
	Unit	0	1	2	3	4	5	6	7	8	9	10	NPV
Progeny	1			0.81	0.73	0.66	0.59	0.53	0.48	0.43	0.39	0.35	4.96
Progeny’s progeny	0.5					0.33	0.30	0.27	0.24	0.22	0.19	0.17	1.71
Progeny of progeny’s progeny	0.25							0.13	0.12	0.11	0.10	0.09	0.54
Overall *NPV Factor*													7.22

** NPV discount factor 10%*

The components of the ASI (milk, protein and fat), SCC and milking speed will become evident when the heifer enters the milking herd and commences milking. This represents a ‘mid life’ contribution. This benefit should then be evident for the duration of the cow’s productive life and be passed onto subsequent generations but only as they themselves enter the herd (see Table 3).

Table 3. Shows NPV of traits that become evident as the replacement enters the milking herd (milk volume, protein, fat, milking speed and SCC).

		Year											
	Unit	0	1	2	3	4	5	6	7	8	9	10	NPV
Progeny	1				0.73	0.66	0.59	0.53	0.48	0.43	0.39	0.35	4.15
Progeny’s progeny	0.5						0.30	0.27	0.24	0.22	0.19	0.17	1.38
Progeny of progeny’s progeny	0.25								0.12	0.11	0.10	0.09	0.41
Overall *NPV Factor*													5.95

- *NPV discount factor 10%)*

Table 4. Shows NPV of traits that become evident later in the productive life of a cow (longevity/survival).

		Year										
	Unit	0	1	2	3	4	5	6	7	8	9	10	NPV
Progeny	1							0.53	0.48	0.43	0.39	0.35	2.18
Progeny's progeny	0.5									0.22	0.19	0.17	0.58
Progeny of progeny's progeny	0.25											0.09	0.09
Overall *NPV Factor*													2.85

- *NPV discount factor 10%*

The 'late' traits (longevity/survival) will not be evident until later in the productive life of the cow and will only be seen later in the life of any subsequent generations (see Table 4).

Note the inevitable delay between the purchase (and use) of the semen straw and the point of time that the cow enters the herd. Allowing for an average of 2.5 inseminations to achieve a pregnancy, normal gestation and the calving of heifers at 2 years old, it is reasonable to apportion this lag to be approximately 2 years for the early traits and 3 years for the milking traits. It may be up to 7 or 8 years for the longevity trait.

The NPV tables (Tables 2, 3 & 4) demonstrate the factor that should be applied to each unit of genetic gain in each trait in question. The $Profit function is based on an index that includes traits that express themselves early, mid and late in the productive life of a cow. For the purposes of the study the NPV factor of the main production traits, has been assumed (i.e. **NPV factor = 5.95**).

Having established the NPV factor it is now necessary to quantify the extent of genetic improvement. Equation (2) shows that the genetic merit of the progeny will reflect the breeding value of the sire and the breeding value of the dam in an individual mating. It should not be assumed that all the progeny produced by this mating will be included in the herd. Only some of the female progeny will be used as replacements. The actual genetic gain is only carried forward by the herd replacements.

Consequently it is better to focus is the difference between the average genetic merit of the replacement females and the average genetic merit of the herd. (This assumes that the average genetic merit of the cows culled from the herd reflects the herd average).

The average genetic merit of the replacement females has two components. The first is the effect of the sire and the second is the effect of the dam. We can separate these effects to simplify the calculations.

Unlike many other livestock industries, there is no opportunity to measure the own performance of dairy replacements prior to them being included in the herd. Accordingly, selection is predetermined by the dams selected to breed the replacement heifers, rather than on the replacements themselves. This highlights the usefulness of the dam effect and this is central to the approach undertaken in this study.

The number of breeders selected to breed replacements will depend on the number of replacements required. In a high performing herd that achieves high conception rates and has a low level of cows culled due to functionality problems, the number of replacements required may be quite low. In a herd that struggles with fertility in their high producing cows and has a high attrition rate in the cow herd as the result of udder or leg problems, and/or clinical or subclinical mastitis, this requirement may be much higher.

Consequently the number of dams needed to breed the herd replacements will vary considerably. The number of replacements required dictates the number dams required. The proportion of dams required affects the difference between the average ABV of the cows selected to breed replacements and the average ABV of the herd. The proportion of dams selected dictates the selection intensity and this combined with the standard deviation of the ABVs within the breeding herd determine the dam effect.

The average ABV of the cows selected can be calculated by the formula:

$$(6) \qquad \textbf{Average ABV}_{\textbf{dams selected}} = \mathbf{i} * \boldsymbol{\sigma}_{\textbf{ABV}}$$

Where (i) is the selection intensity and $\boldsymbol{\sigma}_{\textbf{ABV}}$ is the standard deviation of the ABV's of the dams within the breeding herd.

Since the selection intensity is determined by the proportion of dams selected to breed replacement in relation to the total herd size, a smaller proportion will result in higher selection intensity and a bigger difference between the average ABV of the dams selected and the average ABV of the overall herd.

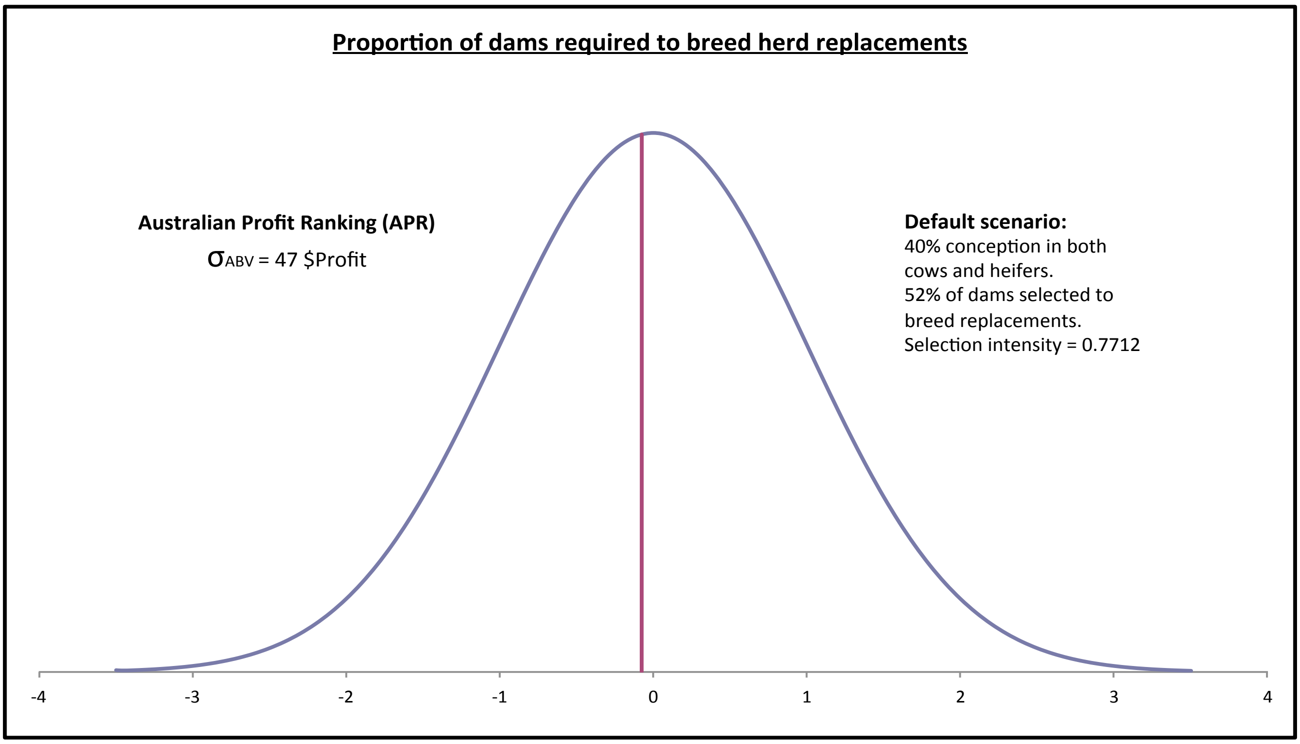

Figure 1. Showing the default scenario (where 52% of the dams are required to breed the herd replacements)

** Source: selint-1 (Brian Kinghorn)*

The dam effect is half the difference between the average ABV of the dams selected to breed the replacement heifers and the average ABV of the herd and is represented by the following formula:

$$\textbf{(7)}\qquad \textbf{Dam Effect} = \tfrac{1}{2}\,(\textbf{ABV}_{\text{dam average}} - \textbf{ABV}_{\text{herd average}})$$

Note that even in a herd that is in a steady state, there will be a dam effect provided that selection has a focused breeding objective. This is acknowledged by the authors (Pryce et al) of the technical bulletin describing the APR (Pryce, J. E., van der Werf J., Haile-Mariam M, Malcolm W., Goddard M. 2010). The chart shown in Figure 1 (above) mirrors the assumptions used in the industry gross margin model used to determine the industry economic values. This is used as a default scenario from which to compare other breeding strategies. In this scenario, 52% of the dams are required to breed the herd replacements. This represents a selection intensity of 0.77. If the standard deviation of the ABV's in the herd is 47 $Profit (for the $Profit function), then the expected difference between the selected dams and the herd average would be 36 $Profit. The dam effect would then be half this difference (i.e. 18 $Profit). The partial analysis model determines this same value in the default scenario outlined later in the paper.

The sire effect is calculated in a similar way. The sire effect is half the difference between the sire ABV and the average ABV of the herd and can be represented by the following formula:

$$\textbf{(8)}\qquad \textbf{Sire Effect} = \tfrac{1}{2}\,(\textbf{ABV}_{\text{sire}} - \textbf{ABV}_{\text{herd average}})$$

If the average ABV of the herd is zero, then the sire effect will be half the ABV of the sire. Note that in the default scenario described above, the ABV of the sire is also assumed to be zero. In this scenario, it is assumed that the semen cost covers the cost of achieving a pregnancy with no investment into genetic gain.

The overall effect is the sum of both the sire and dam effect.

$$(9)\qquad \textbf{Genetic Gain}_{\textbf{progeny}} = \textbf{Sire Effect + Dam Effect}$$

The partial analysis model used in this study calculates both the dam effect and the sire effect separately. The working are shown in the attached spreadsheet model, as are the herd dynamic associated with each scenario.

The total genetic gain in relation to the herd is the overall effect multiplied by the number of replacement heifers included in the herd. This is calculated by the partial analysis model and can be shown as follows:

$$(10)\qquad \textbf{Genetic Gain}_{\textbf{herd}} = \textbf{Gain}_{\textbf{progeny retained}} * \textbf{No.}$$

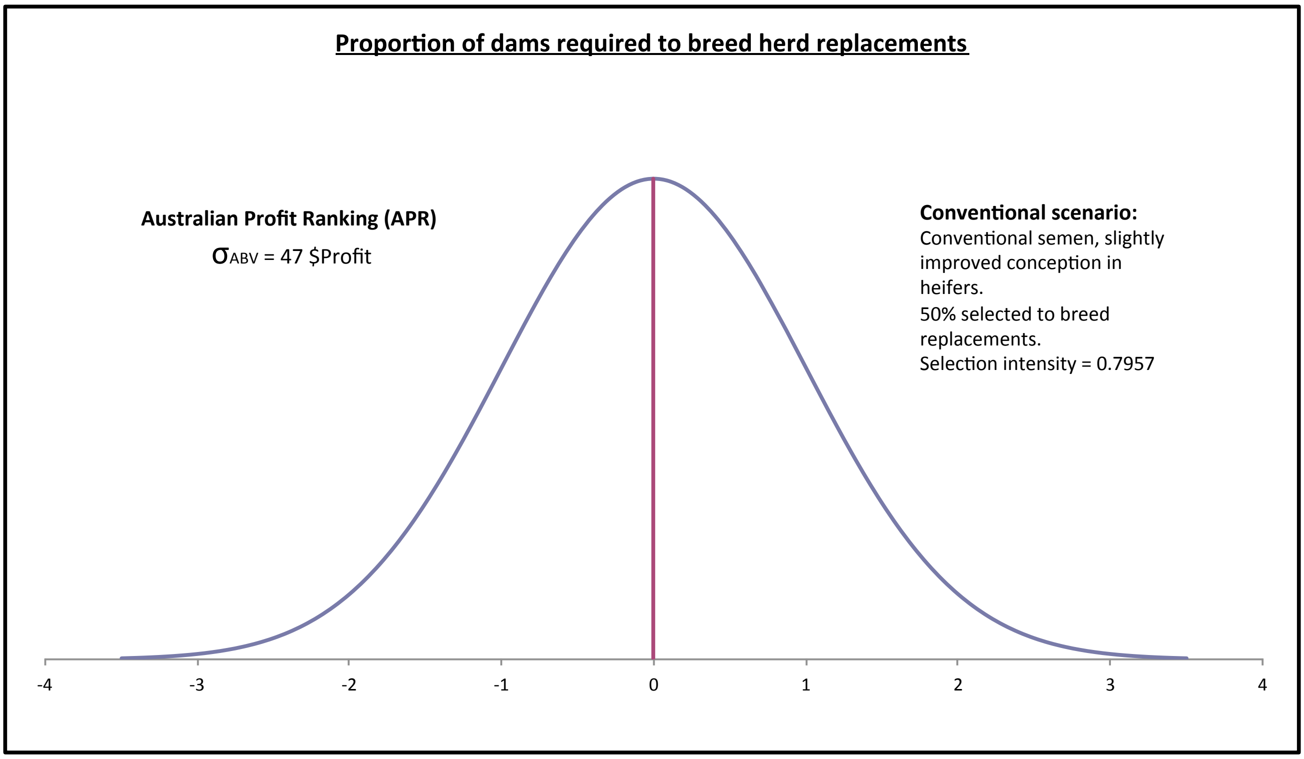

Figure 2. Showing the improved herd conventional semen scenario (slightly higher conception in heifers) * *Source: selint-1 (Brian Kinghorn)*

The calculations involved are made simpler if it is assumed that the herd involved is ‘representative’ or “average”. As such the average herd ABV will be zero. We have already simplified the calculations by using the $Profit function as the ABV value. In this case the genetic gain will be the overall effect (i.e. change in $Profit function of the progeny) multiplied by the number of replacement heifers retained and included in the herd.

Given that the economic value assigned to the $Profit function is one (1 AUD), the value of the genetic gain can be calculated accordingly. If we wish to calculate the absolute value of the genetic gain we can multiply this by the assumed NPV factor. The partial analysis model includes this in its calculations.

Having calculated the NPV of the genetic gain, we must now examine the investment. There are several aspects to consider. Firstly, the farm model requires a pregnancy for cows to calve and commence lactation. Without lactation, there is no milk production. This is independent of any genetic gain. Hence the cost of semen has a component that is akin to an operating cost. The steady state model used to calculate economic values assumes a semen cost of $16 per straw. It is assumed that this is required to achieve pregnancy (and the subsequent lactations) but have a neutral effect on genetic gain. As mentioned, the steady state described by the industry gross margin model (Pryce, J. E., van der Werf J., Haile-Mariam M, Malcolm W., Goddard M. 2010) includes a small genetic gain as a dam effect so that the ABV of the sire will be need to be marginally lower than the herd average if there is to be no change to the genetic merit of the herd.

For the purposes of this study, the semen cost used in the steady state industry model is assumed as the default value (i.e. $16 per straw) and the genetic merit of the sire in this case is assumed to be zero $Profit (the same as the average $Profit ABV of the herd). Any genetic merit above this value is considered as an investment into genetic gain.

The base line investment into genetic gain is therefore depicted by the following formula:

(13) $I_1 = (\text{Price of semen} - \text{default value})$

Where I_1 is the investment required per insemination.

Obviously, the investment required to achieve a pregnancy, maintain genetic merit and/or invest in genetic gain is not simply the cost of a single straw of semen. Several inseminations may be required to achieve a pregnancy. There are, therefore some arbitrary positions to take in the investment equation. The first determination is the total number of inseminations.

The total investment is then the I_1 multiplied by the number of inseminations.

(14) $I_{1\ total} = I_1 * \text{Number of inseminations}$

The partial analysis model determines a herd structure based on an anticipated conception rate. This in turn determines the number of inseminations based on the same anticipated conception rate and the corresponding returns to service. Using the default scenario parameters the number of inseminations per breeder is determined by the model to be 2.27.

The investment in semen is not, however, the only cost consideration. Each insemination has an associated breeding cost that contributes to the total cost of production.

These formulae may at first seem pedantic, but they allow us to work logically through the investment equation. They feature in most of the partial analysis equations and the reason for such detail becomes evident when assessing the economic benefit of utilizing more advanced reproductive products in subsequent papers.

The importance of this becomes more evident in subsequent papers that compare some of the products derived from more advance reproductive techniques.

The next parameter to consider is the number of inseminations required to achieve pregnancy. The industry model (Pryce, J. E., van der Werf J., Haile-Mariam M, Malcolm W., Goddard M. 2010) refers to an average of 2.5 inseminations to achieve a pregnancy. This incorporates two factors. The first is the total number of inseminations used on cows that fail to conceive (and are culled on the basis of infertility). The second is the insemination of cows that are successfully made pregnant. Any cows that fail to be in calf after five inseminations are culled in the industry model. This study assumes the same in the default scenario. The conversion of the number of inseminations per cow to the number of inseminations per pregnancy is an important factor since it dictates the number of breeders culled for infertility. For convenience we can call this the I_2 conversion factor:

(15) $I_{2\ \text{conversion factor}}$ = Average number of inseminations required per pregnancy/average number of inseminations required per cow

When using conventional semen, half the progeny will be male. The partial analysis model assumes the male calves to half no commercial value. This may not entirely reflect the real commercial situation since most farmers salvage a small commercial value for their male calves. For the sake of the modeling it is simpler to disregard this income stream. The investment required to generate a female calf is therefore calculated by dividing the investment required to achieve a pregnancy by the male/female ratio. Conversely we can express this as:

(16) $I_{3\ \text{conversion factor}}$ = Total number of calves/total number of female calves

Not all calves survive. A further figure is required that reflects the number of female calves reared. Exact industry figure are difficult to obtain, however actual survival rates are reported to be much higher than they are generally perceived. The survival rate used within the partial analysis model is 80%. This is consistent with work conducted in the United States (Hare, Norman and Wright 2006) that may or may not accurately reflect the situation in Australia. Note that this parameter used in this study may differ from the one used in the industry model since the survival rate is not clearly identified in the supporting literature. Preliminary parametric work suggests that this figure has a dampening, rather than altering affect on differences between strategies. The represents the I_4 conversion factor therefore becomes:

$$\textbf{(18)} \qquad \mathbf{I_{4\ conversion\ factor}} \quad \mathbf{= 1/survival\ rate}$$

The preceding discussion has outlined how the partial analysis model determines the amount and value of genetic gain by determining both a dam and sire effect and placing them in an investment analysis framework. The discussion has then describes a series of factors that relate to the number of inseminations required to produce a replacement heifer. The investment in semen is not, however, the only cost consideration. Each insemination has an associated breeding cost that contributes to total cost of production.

If the focus is simply on genetic gain then a focus on the investment equations outlined above is valid. However, if the focus is on both the females retained and the surplus females that are sold, then it is better to incorporate the cost of inseminations into a cost of production figure. The partial analysis model has been designed to generate a cost of production that includes the breeding cost and the cost of growing the replacement heifer to a target mating weight.

The breeding cost is determined by the number of inseminations and includes the cost of semen, the insemination cost and the cost of pregnancy diagnosis. The cost of growth is determined by a fixed cost of gain. A target weight of 280kg is assumed.

The cost of production is important for two reasons. Firstly it is required to balance the benefit of genetic gain. Genetic gain comes at a cost and this must be included in the profit equation. Secondly it forms the basis of the profit equation used to calculate the income from sales. This is calculated against the market value to determine a margin. The overall income is the margin multiplied by the total number of replacement sales.

Note that the partial analysis model only factors the sale of replacement females. The model overlooks the sale of cull cows. This is a reasonable assumption at this point, however, it should be pointed out that the sale of a mature cow, even at a modest c/kg live weight has some value.

The method described above enables us to calculate the absolute value of genetic gain and the investment required to achieve it. It has the capacity to factor the difference in fertility that may be anticipated with different reproductive products. It also factors additional heifer sales and their cost of production. However, to take this to its logical conclusion these values need to be placed into an investment stream to determine an overall NPV of the investment (or breeding) strategy.

Results

To demonstrate the workings of the model, a default scenario is compared to a slightly more commercial scenario that utilizes conventional semen in a bid to achieve some level of genetic gain. As mentioned, the default scenario aims to mirror the parameters held within the industry gross margin model. The more commercial scenario utilizes better quality conventional semen that offers significant genetic gain and factors a slightly better anticipated fertility in heifers. The key parameters associated with each scenario are depicted below.

Table 7. Comparing the herd size and structure in each of the scenarios.

	Conception rate		Herd size *	Replacement females generated*	Replacement females required*	Number of dams needed to breed the required number of herd replacements*	Surplus heifers *
	(cows)	(hfrs)					
Default	40%	40%	137	50	26	71	24
Conventional	40%	60%	137	52	26	69	26

** These parameters have been determined by the partial analysis model.*

The conventional scenario is $14,692 more profitable based on a discounted NPV (see Table 14). The detail in regards to this comparison is contained in the attached spreadsheets.

Table 14. Comparing the total NPV within each of the scenarios

	NPV Dam effect	NPV Sire effect	Total NPV of genetic gain	Cost of production adjustment	NPV of additional sales	Total NPV	Difference
Default	$2,788	0	$2,788	0	0	$2,788	
Conventional	$2,877	$16,058	$18,935	-$990	-$464	$17,481	$14,692

Discussion

This paper describes in some detail, a method that determines the absolute value of genetic gain within an investment analysis framework. Accordingly, the key difference in the approach is to view genetic gain in terms of costs and benefits over time. The approach acknowledges the timing in which the benefits of genetic gain contribute to the farm cash flow. This is achieved through the use of a detailed partial analysis model.

References

ABS 2010, *All breeds sire directory 2010*: ABS Australia. pp. 1-72.

ADHIS 2012, *Selectabull - adhis tool*,

ADHIS publication 2010a, *Apr updated formula*, viewed <http://www.adhis.com.au/v2/downv2.nsf/0/5957c1e5b8cdfaebca2576ef000c18db?open%3E.

ADHIS publication 2010b, *Introducing apr 2010 brochure*: Australian Dairy Herd Improvement Service (ADHIS). pp. 1-18.

ADHIS publication 2010c, *Technote 13 - australian profit ranking (updated formula)*: Australian Dairy Herd Improvement Service (ADHIS). pp. 1-2.

ADHIS publication 2012, *The good bulls guide - april 2012*, Australia Dairy Herd Improvement Service & Dairy Australia: ADHIS. pp.

Bekman, H & van Arendonk, JAM 1993, 'Derivation of economic values for veal, beef and milk production traits using profit equations', *Livestock Production Science,* vol. 34, no. 1-2, pp. 35-56.

Dekkers, JCM & Gibson J.P. 2009a, 'Chapter 6 - economic selection indices' in *Course notes - animal genetics - design and economics of animal breeding strategies* University of New England.

Dekkers, JCM & Gibson J.P. 2009b, 'Chapter 7 - deriving economic weights' in *Course notes - animal genetics - design and economics of animal breeding strategies* University of New England.

Groen, AF 1988, 'Derivation of economic values in cattle breeding: A model at farm level', *Agricultural Systems,* vol. 27, no. 3, pp. 195-213.

Groen, AF, Steine, T, Colleau, J-J, Pedersen, Jr, Pribyl, J & Reinsch, N 1997, 'Economic values in dairy cattle breeding, with special reference to functional traits. Report of an eaap-working group', *Livestock Production Science,* vol. 49, no. 1, pp. 1-21.

Haile-Mariam, M, Bowman, PJ & Goddard, ME 2010a, 'Calculation of lifetime net income per year (ltni/year) of australian holstein cows to validate the australian profit ranking of their sires. 1. Genetic analyses and prediction of ltni/year for cows still in the herd', *Animal Production Science,* vol. 50, no. 8, pp. 757-766.

Haile-Mariam, M, Bowman, PJ & Goddard, ME 2010b, 'Calculation of lifetime net income per year (ltni/year) of australian holstein cows to validate the australian profit ranking of their sires. 2. Validation of the australian profit ranking of sires and test for genotype by environment interaction based on ltni/year', *Animal Production Science,* vol. 50, no. 8, pp. 767-774.

Hare, E, Norman, HD & Wright, JR 2006, 'Survival rates and productive herd life of dairy cattle in the united states', *Journal of Dairy Science,* vol. 89, no. 9, pp. 3713-3720.

Mulder, H, Jansen G. 2001, *Derivation of economic values using lifetime profitability of canadian holstein cows*: Occasional Paper produced by the Centre for Genetic Improvement of Livestock, University of Guelph, ON, Canada. pp. 1-10.

Olynk, NJ & Wolf, CA 2009, 'Stochastic economic analysis of dairy cattle artificial insemination reproductive management programs', *Journal of Dairy Science,* vol. 92, no. 3, pp. 1290-1299.

Pearson, RE & Miller, RH 1981, 'Economic definition of total performance, breeding goals, and breeding values for dairy cattle1,2', *Journal of Dairy Science,* vol. 64, no. 5, pp. 857-869.

Pryce, JE, J. H. van der werf, M. Haile-Mariam, B. Malcolm and M.E. Goddard 2010, 'Updated index weights for australian profit ranking in dairy cattle', *Proc. Assoc. Advmt. Anim. Breed. Genet,* vol. 18, no., pp. 143-146.

Pryce, JE, van der Werf J., Haile-Mariam M, Malcolm W., Goddard M. 2010, *A technical manual describing the australian profit ranking (apr) index (version 2)*: ADHIS. pp. 1-73.

Schneeberger, M, Barwick, SA, Crow, GH & Hammond, K 1992, 'Economic indices using breeding values predicted by blup', *Journal of Animal Breeding and Genetics,* vol. 109, no. 1-6, pp. 180-187.

Simm, G 1998, 'Genetic improvement of cattle and sheep', *Farming Press,* vol. no., pp.

van Arendonk, JAM 1985, 'A model to estimate the performance, revenues and costs of dairy cows under different production and price situations', *Agricultural Systems,* vol. 16, no. 3, pp. 157-189.