ECONOMIC CONCEPTS IN THE VALUATION OF "PRODUCTS" USED IN DAIRY PRODUCTION INCLUDING A REAL OPTION'S APPROACH

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Dairy production yields per cow continue to improve over time. New concepts in animal management and nutrition and genetic selection have contributed to these improvements. In concert with this progress, a vast array of "products" have been developed (bypass fats, buffers, bypass protein supplements, BST, breeding synchronization programs etc.) to facilitate continued evolution of improved production/cow. The modern dairy producer can be viewed as a manager of an investment portfolio, where various investment opportunities (products, management interventions) must be selected and combined in a manner to provide a profit at competitive risk to alternative opportunities. The modern producer and his consultants must not only have a firm understanding of the underlying dairy production system from a biological perspective, but also must have a concrete understanding of economics by which to measure value of decision opportunities.

The purpose of this paper is to review concepts in economics and traditional methods used to evaluate product investment opportunities in dairy herds and to present new approaches. The basic economic attributes of investment opportunities will be discussed (magnitude, direction, timing, variability, uncertainty, and flexibility).

The framework of the typical investment problem

The decision to use or not use a product in a dairy herd is one that is routinely faced on all dairies. In fact, by defining "product" as any investment opportunity such as the use of a feed supplement or a new breeding program, can make one immediately see how prevalent these types of decisions are on the modern dairy. Basically, an investment is made in the product as well as other inputs (feed, labor etc) and it is hoped that the return (often valued in terms of milk response or improved reproductive efficiency or survivability) is of greater value then the

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costs. Additionally, it is hoped that the return for the investment is greater then any alternative opportunity available to the producer.

A common attribute of all these types of decisions and one which greatly simplifies economic calculations is that the vast majority of producers making these decisions have decided to “stay” in the industry and thus can evaluate any presenting opportunity on a marginal basis. Only changes in costs (increases and decreases) as well as changes in revenues (increases and decreases) associated with the product must be considered. All other cost (mortgage payments, tractor payments, utilities etc) referred to as “fixed cost,” will be paid irrespective of the decision to use or not to use a product and thus are irrelevant to the decision. They can be ignored in the decisions regarding product use or in the ranking of various opportunities. The term marginal analysis or partial budgeting analysis is often used to describe this type of economic evaluation. This fundamental principle greatly reduces the number of items one must evaluate when determining the value of a product. For an investment opportunity to be potentially viable, the net of these changes must be positive.

The concept of the partial budget analysis can be extended to products that can be used over a range of levels (lbs of product, dose level, etc). For each input level a partial budget can be constructed and the level that yields the largest net value is the point of optimal use for the input. This point can also be determined by evaluating the marginal changes in revenues and the marginal changes in cost for each change in input level. When these values are equal determines the optimal input level that will maximize net profits.. In figure 1, an example input function is described where only changes in revenue and variable cost are considered.

For each input level, a revenue is generated as well as a variable cost with the net difference either being negative or positive. Inputs above 3 units result in a net positive difference between returns and cost. As higher levels of inputs are used, one observes an increasing difference between revenues and cost and then a decreasing difference (beyond 6). The optimal point of usage for this input would be six units – levels below and above this point will yield a profit (positive net revenue and cost) but not as large as the profit at six units.

Determining the magnitudes of cost and returns

For many products used to improve production, the cost components consist of the product cost, its implementation, as well as any associated changes in dry matter intake. The return is often the value of the improved milk production and/or changes in milk composition. Some products might suggest having a number of production dimension effects (milk production / composition and reproductive efficiency) and thus greatly complicate an analysis. Further complication arises when these effects occur over an extended time horizons. Simulation modeling can be used to estimate the value of products having multiple dimensions over time.

Basically, for any product or investment opportunity, all cost and returns must be identified and scaled on a per animal and time basis. For example, anion/cation supplements are fed to supposedly reduce the incidence of milk fever. Generally, the supplements must be fed to all dry cows (1^{st} , 2^{nd} and 3^{rd} or greater lactation numbers) while only cows 3^{rd} lactation or greater are at risk of having milk fever. The practical delivery of the supplement inflates the cost (i.e., non-risk cows must be fed), and the benefits are limited to the portion of cows at risk of milk fever.

Timing of costs and returns

The timing of when costs are due and returns realized can influence the value of the product because the producer can use either funds for an alternative opportunity over a given time horizon. Basically, products that have an immediate large cost and a long time horizon until the realization of a return will have lower value than products of similar scale having lower cost, or cost due at future dates and a short time horizon to the realization of a return. To account for the differences in value associated with the timing of cost and returns, discounting has been used to represent all cash flows on a “today” basis or present value basis (Brealey and Myers, 2000).

Present Value = $C_t\ /(1+r)^t$

Where,
C_t = is either a cost or revenue at time t,
r = the return of an alternative opportunity.

The net present value (NPV) a gold standard metric in economic analysis is merely the sum of present values:

Net Present Value = $\Sigma\ C_t\ /(1+r)^t$,

C_t = the cash flows at time t associated with a product.

Note for cash flows occurring today (often the "cost of the investment") the discounting factor 1/(1+r) becomes 1 when t =0.

The basic interpretation of the NPV is that if it is greater than $0 then the product opportunity offers a return greater than the alternative opportunity, r. If the NPV is equal to zero, then the return on investment on the product is equal to the r value. The selection of r will influence the underlying value of an investment opportunity. If one was to use a very low r (t-bill rate) of 4-5% one would be accounting for the pure time value of money effects. The return on the t-bill is almost certain (low risk) unless the US government is going to fold. However investments in products often have a high degree of uncertainty and thus, a higher r value is used to reflect additional risk. Ideally, it should reflect the returns of an alternative investment of similar risk, however, one usually uses the return to capital experienced by the dairy at large.

One could effectively argue that many costs are "risk" free (for example the cost of the product) in that they can be identified and are known with certainty and, therefore, should be discounted at the risk-free rate (t-bill rate). While the return component, (for example the value of the milk production response) is more risky and, therefore, these components should be discounted with a higher value of r.

For many feed supplement products that immediately improve milk production, cost can be paid on a timely basis corresponding to the production response. Additives to silages, however, often require an upfront cost while returns are realized at a future date as the silage is fed to the herd. One should always use discounting when time dimensional effects are present – failing to do so can distort one's estimate of the value of a product. The NPV function in Excel greatly facilitates this calculation.

Extensions to the NPV calculation

There are other economic metrics that are useful to be familiar with that result from NPV calculations.

Internal rate of return

The internal rate of return (IRR) is one, for example, that has already been referred to. It is the value that r must take for the NPC calculation to be equal to zero. Figure 2 shows an example calculation where the initial investment is $4000 with a revenue of $2000 realized in year 1 and $4000 realized in year 2. When an r value of 28% is used, the NPV = zero, so the internal rate of return is

28%. When the r value is below this level, the NPV calculation will be positive (i.e., the investment offers a higher return).

Often the IRR is used to compare investment opportunities, however, problems arise when the investments being considered vary in their scale of investment. Another problem is that often the time scale of the return is not defined or is different for the various products being considered. For example, the time frame for BST is two weeks, while the time frame on a systematic breeding program is years. The IRR function in Excel can perform this calculation on a stream of cash flows.

Constant payments per time period (Annuities)

Often one calculates the NPV on a variety of investment opportunities and the central dogma is to select the NPV that is the highest. This is a good rule of thumb if the time dimensions of the projects are similar. However, when projects have greatly different time horizons one has to be careful on merely comparing NPV calculations. A neat metric is the annuity value concept. Any NPV estimate (i.e., calculated from a series of uneven cash flows) can be represented by an equal valued annuity of constant cash flows/period over the same time horizon. This annuity value can then be compared across the different products or decision strategies to find the optimal point. The annuity value thus accounts for the time value of money as well as the time horizon of the project.

Annuity value = $C_t/r- (C_t)/(1+r)^t$

Where C_t is the constant cash flow per period for t years.

Often one is interested in calculating the C_t equivalent for a NPV calculation:

$C_t= NPV(1/(1/r-1/(1+r)^t)$

Excel PMT function performs this calculation.

Risk, Variability and Uncertainty

Many products or investment opportunities have cash flows (revenues sources or cost) that are uncertain, due to the inherent variability of the biology and/or the lack of knowledge of the system (Galligan et al., 1987). Often times the response component is variable (i.e., milk response is not constant) while the cost components are known with certainty. (Note: The distinction between variability and uncertainty is important in terms of knowing whether additional information will improve one's knowledge of the system – i.e., sampling more cows, while variability will only be changed if the underlying production system is manipulated – understanding how a product works biologically.)

Several approaches can be taken to evaluate uncertainty in response and/or cost. One could do the analysis with all the variable inputs at their mean levels, one could look at extreme values for the various variable parameters (often called scenario analysis), or one could vary the items over a plausible range and look at the resulting output (sensitivity analysis). A universal problem with these methodologies is that they do not account for the frequency of the various levels for the variable in question. Simulation modeling allows one to account for the frequency at which extreme outcomes are likely to occur and account for any correlation that might exist between input variables.

An approach we have found useful to look at products with variable output responses is the Type I and II error analysis approach (Galligan et al., 1991). Basically this approach looks at the variation in response and determines a breakeven level of response needed to cover the cost of using the product (Figure 3). Type 1 errors occur when the product is used and the response is below break-even, while type 2 errors occur when the product is not used and the response would be above break-even. The underlying variability of the response variable (i.e., milk production etc.) can be used to estimate the frequencies of the errors as well as their expected cost (Figure 4). A product that has a type II error which is greater the type I error should be considered for use. In this situation, the cost of failing to use a product (i.e., lost opportunity) is greater than the cost of using the product and having it fail. For the example of using sodium bicarbonate, the type 1 error is $.01/cow/d while the type 2 error is $.21/cow/d. A spreadsheet version of this program is available at the following web site: http://cahpwww.vet.upenn.edu/software/apps.html. The Church and Dwight Company supported the program's development.

When several products are being considered, each having a variability component and thus different risk characteristics, one can use stochastic dominance approaches. Basically, the cumulative distribution of the net partial budgets for the various products can be overlaid. Products with curves to the right are superior in that a higher value is obtained for each level of frequency.

New improved method: REAL Options Analysis

The last method and one which I think is extremely exciting is real options analysis (ROA). Up to this point all the methods of valuation have explicitly assumed that management is passive in the decision investment process. They have assumed that management will make investments and live with the consequences. For some investments this is true, while for many, management does not have to be passive but can respond to resolved variability midpoint in the investment (Hull, 2000).

Consider two feed related products having the same mean milk response of 8 lbs and a standard deviation of 4 lbs. However, product one is a supplement added to the feed on a daily basis while product two is added to the haylage. They both cost the same on a per cow basis and let us assume that the production response can be estimated at some point in the future. Traditional analysis (NPV calculations) would value these two products equally – their mean response, variability and cost are all equal and therefore their NPV calculations would be equivalents. However, for daily feed supplement, one could argue that there is additional value to this product in that management can assess the response (2-3 months) and determine whether to continue investing – this is called "real option value." While product two has relatively near zero option value in that the producer must live with the consequences (the level of response) – he has to wait until the end of the haylage feeding to determine whether to continue.

Products that allow for management to intervene and make changes as uncertainty is resolved mid-stream have additional value that has not been estimated. One could say that these products are an opportunity of investment and not an obligation and thus have an element of flexibility that can be extremely valuable. It is this attribute of managerial discretion to participate in an asymmetrical distribution of responses that draws parallels to financial options (puts and calls on stocks). When one purchases a call on a stock price, one is buying the right to further invest at a future date at a given price for the stock (strike price). One will exercise the option if the price of the stock in the future is above the strike price but one is not obligated to do so. One can choose to not exercise the option and would do so if the price of the stock were below the strike price. The value of such an opportunity is captured in the price of the call option.

To estimate the value of these financial puts and calls, Scholes, Mertin and Black developed an analytical solution for which they received the Noble Prize in economics in 1997. This methodology can be used to evaluate "real" options in addition to financial puts and calls. Below is the basic equation used to estimate the value of a call option. The parameters are defined for real options as well as financial options.

$$\text{Call option value} = C(S, t, E) \equiv S\,N(d_1) - Ee^{-rt}\,N(d_2)$$

where

$$d_1 = \{ \log(S/E) + r_f + \sigma^2/2 \} / (\sigma\, t/2)$$

$$d_2 = \{ \log(S/E) + r_f - \sigma^2/2 \} / (\sigma\, t/2)$$

where:

Real option	Financial option
E = price to be paid to attain the assets	Exercise price of the option
S = the present value of future cash flows	Stock price
t = time to future investment	Time to maturity
σ^2 = variance of future cash-flows per year	Volatility of stock price
r_f = continuously compounded risk free rate of interest	

Consider a hypothetical product that cost $.40/cow/day and results in an 8.6 lb milk response with a standard deviation of 4.6 lbs (Figure 5). Using a risk free discount rate of 5% one would calculate a traditional NPV of $37.54/cow/year. However, by using the real options approach this products true value is $58.01/cow/year. In short, management on a dairy has value (in this case to assess if the response is above breakeven) that can influence the value of products having a variability component (Gronendaal and Galligan, 2001).

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Figure 1) Production Curve

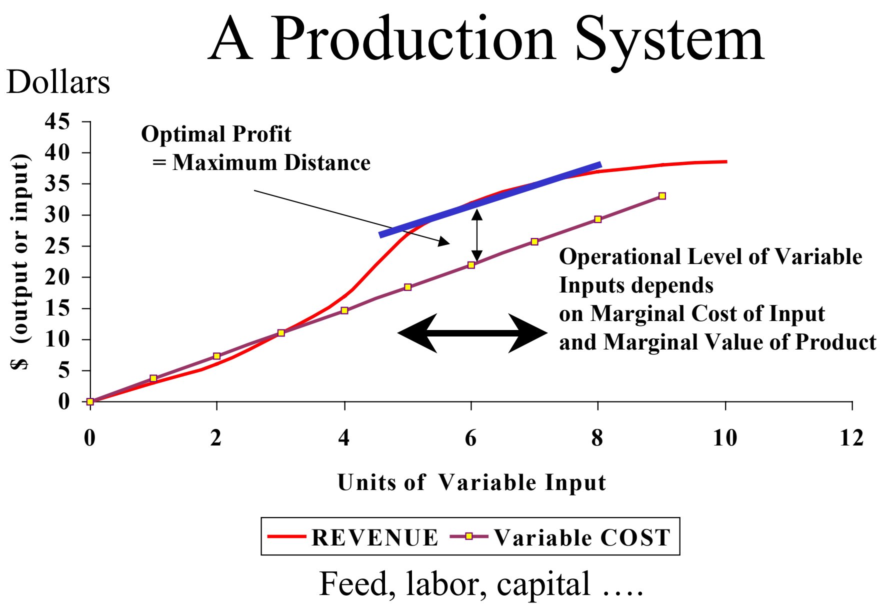

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Figure 2) Investment Example for Calculation of Internal Rate of Return

An example investment opportunity

Investment	Co	C1	C2
A	-4000	2000	4000

INTEREST	NPV
0	$2,000.00
0.05	$1,532.88
0.1	$1,123.97
0.15	$763.71
0.2	$444.44
0.25	$160.00
0.3	($94.67)
0.35	($323.73)
0.4	($530.61)
0.45	($718.19)

NPV goes negative
At @28%

Figure 3) Variation in Response to Sodium Bicarbonate Feeding

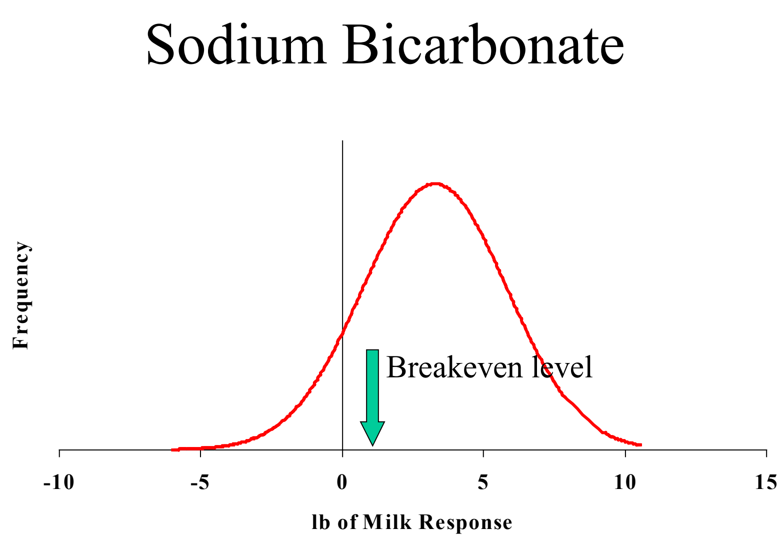

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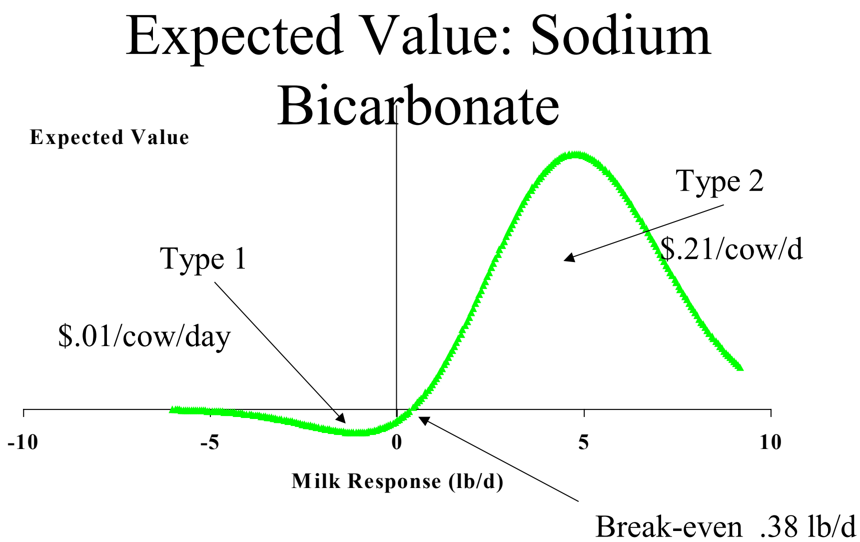
Figure 4) Expected Value of Responses



Sodium Bicarbonate

Figure 5) Real Options Analysis on a Hypothetical Product

Milk $/cwt	$ 10.00
Feed Cost marginal	$ 0.03
Product Cost /d	.40
Days on product/year	200
Milk response/cow/d	8.6
Uncertainty of response	4.6
r risk free	0.05
r adjusted	0
Net Revenue/cow/year	$ 172.00
Total cost/year	$134.46
Net value per year	$37.54
rate of return	28%

Method 1 of calculation:
Binomial

Option value Binomial $ 59.46

Method 2 of calculation:
Black Scholes:

Black scholes $ 58.01