Working Paper

Economic Consequences of Extending the Calving Intervals of Dairy Cows Treated With Recombinant Bovine Somatotropin.

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Abstract

In response to a new recommendation that extending calving intervals to 18 months when dairy cows are treated with recombinant bovine somatotropin (rBST), an analysis was performed to see if the management practice was economically justified. This analysis was performed using a capital budgeting technique known as net present value analysis that accounts for the costs one incurs on economic returns that are received over time versus immediately. Results of this analysis are consistent with those of previous analyses that concluded that maximum net economic returns are earned when the calving interval is 12 to 13 months versus 18 months. Based on this finding it appears that even with the introduction of rBST it advisable for dairy producers to manage for calving intervals that are as short as possible.

Numerous studies have been conducted through the years that have concluded that dairy producers can lose potential profits as calving intervals are extended (2, 4, 5, 6, 8). As such, it has generally been accepted that dairy producers should be attempting to manage for 12 to 13.5 month calving intervals.

In recent years recommendations for extending calving intervals to 18 months when cows are treated with recombinant bovine somatotropin (rBST) have appeared in the popular press (7). The logic underlying this recommendation is that there is less need to initiate another lactation in a cow because rBST causes cows to give more milk in the later weeks of lactation.

This paper reports the result of a study that was performed to evaluate the merits of this newest recommendation about calving intervals for cows treated with rBST. We first consider the economics of the milk production process and then discuss a methodology for evaluation the economic consequences of extending calving intervals in diary operations. Finally, results of various analyses are reported that address various questions of how calving intervals affect profits in dairy.

Milk Production as an Economic Process

The lactation of a dairy cow can best be described as a repetitive process that begins with the birth of a calf and ends with a 6 to 9 week period where a cow is “dried-up” so that she can get into condition to give birth to another calf. Between the time of the calving and the dry period the dairy cow is milked. During the period a cow is being milked, her milk production varies. Initially milk production increases each week until it peaks sometime around the sixth to ninth week of lactation and then it declines in subsequent weeks (3).

The length of the dairy production process just described depends on the calving interval; which is the amount of time that passes from the birth of one calf to the next. The minimum achievable calving interval is 12 to 12.50 months but the calving intervals of 13 or more months are common for the norm for commercial dairy operations. These longer calving intervals occur when producers are unable to get cows impregnated in a timely manner.

The early weeks of a cow’s lactation are more profitable than the later ones because a cow gives more milk early in her lactation (1). This is an important point because it suggests a producer can maximize profits over time by making sure a cow is at peak production as frequently as possible. This is done by keeping the calving interval to a minimum because a cow gets back to peak production sooner if she is calving every 13 months versus every 16 months.

Treating cows with rBST increases the overall productivity of cows but it does not alter the general production pattern of cows. Milk production still reaches a peak and then declines over subsequent weeks. The fact that cows treated with rBST exhibit the same pattern of production as untreated cows is important because it suggests that producers should be managing cows treated with rBST just as they would untreated cows. The goal in both cases should be minimizing the length of calving intervals because this management practice ensures that peak periods of production are experienced as frequently as possible.

Evaluating Investments Over Time

Purchasing a dairy cow that will yield returns over three or more years is an investment decision that is essentially the same as the decision one makes when purchasing stocks, bonds, or real estate. In all of these cases one commits capital to an investment that will yield returns over time. The goal in making of these investments is to earn maximum profits. Since the purchase of a cow is the same as any other investment activity it follows that the techniques used to evaluate the profitability of investments like stocks and bonds can be applied to decisions dairy cattle investments. In this section we will consider some of the concepts of investment analysis that will be the basis of this study.

The profitability of an investment is partially determined by the level of the returns yielded by the investments but it is also determined by the timing of the returns. Time has an effect on investment profitability because a cost is incurred any time there is a delay in receiving a return on an investment. Economists refer to this as the opportunity cost of capital.

The opportunity cost of capital is the interest earnings one could earn from the best alternative use capital. This cost is incurred on all investments and accounts for the fact that one has to forgo interest earnings from one investment, say a certificate of deposit, when capital is instead committed to the purchase of a dairy cow.

Discounting is a methodology that is used to account for the opportunity cost one incurs when undertaking an investment. With discounting one computes the present values of all cash flows that will be received from an investment over time. By making this valuation adjustment, one accounts for the potential interest earnings one forgoes when returns are received over time versus immediately.

The concept of discounting is illustrated in the example presented in Table 1. For this case it is assumed an investment, costing $60, yields an annual return of $20 per year for four years when the opportunity of capital is 8%. The returns for the investment are reported in the second column of the table and the discount factors that apply to these returns are reported in the third column. The values in the right hand column are the present values that are computed by multiplying the cash flows by the corresponding discount factors. The net present value presented at the bottom of the table was obtained by summing the reported present values.

TABLE 1: Example of Discounting and the Computation of Net Present Values

Year	Cash Flow ($)	Discount Factor (8%)	Present Value ($)
0	-60.00	1.0000	-60.00
1	20.00	.9259	18.518
2	20.00	.8573	17.146
3	20.00	.7938	15.876
4	20.00	.7350	14.70
		NET PRESENT VALUE	**6.24**

The present values reported in the above table show that the value of a $20 return diminishes over time. This is evidenced by the fact that the present value of the $20 received in year 1 is $18.518 while the value of the $20 received in year 4 is only $14.70. This inverse relationship between value and time, which is reflected by the discount rates presented in the table, is the reason why it is one's preference is to receive returns from an investment sooner versus later.

The analysis laid out in Table 1 is an example of a capital budgeting technique known as net present values analysis. This methodology is the most accurate procedure for evaluating investments because it accounts for the opportunity costs one incurs on capital due to the fact that returns or earned over time versus immediately. With present value analysis an investment is judged to be profitable and acceptable whenever the net present value is positive.

In some cases one may be faced with the problem of choosing between two recurring investment alternatives with different lives. For example, one investment option may yield returns over four years while another yields returns over five years. These differences in the lives of the investments have to be taken in to account as well when choosing between investments. One way of doing this is computing what is called an annuity equivalent.

An annuity equivalent is computed in two steps. First the net present value of an investment is computed just as was done in the previous example. Next the net present value is multiplied by an annuity factor which corresponds to the life of the investment. This annuity factor reflects the annual return one could receive over the life of the investment for each dollar that is presently on hand The product of the net present value and the annuity factor is an estimate of the periodic net payment one would receive each year of the investment's life. This procedure for computing annuity equivalents for investments is illustrated in the example detailed in Table 2.

Table 2: Example Illustrating the Use of Annuity Equivalents in Evaluating Recurring Investments with Unequal Lives

		Cash Flows ($):		Present Values ($):	
Year	**Discount Factor**	**INV A**	**INV B**	**INV A**	**INV B**
0	1.0000	-60.00	-60.00	-60.00	-60.00
1	.9259	20.00	20.00	18.518	18.518
2	.8573	20.00	20.00	17.146	17.146
3	.7938	20.00	20.00	15.786	15.786
4	.7350	20.00	20.00	14.700	14.700
5	.6806		1.50		1.021
	Net Present Value			6.24	7.621
	Annuity Factor			.3019	.2505
	Annuity Equivalent *(Product of net present value and annuity factor)*			1.999	1.819

For this example one has the option of choosing Investment A (INV A) or B (INV B) which yield the cash returns detailed in Table 2. INV A has a four-year life and the life of INV B is five years. Both of these investment cost $60.00 (the –60.00 reported for year 0) and yield annual returns of $20 per year in years 1 through 4. The only difference between these two investments is that INV B yields an additional $2.50 of return in year 5.

The net present values reported for Investments A and B are 6.24 and 7.942, respectively. Given these net present values one might conclude that INV B is the preferred investment because it results in the higher total return. However the annuity equivalents for the two investments show that INV A is the preferred investment because it yields an annual return of 1.999 per year while INV B only yields an annual return of $1.989.

The lower annual return for INV B is explained by the fact that this investment takes five years to yield returns worth $7.92 while INV A only takes four years to generate returns valued at $6.24. Because INV A has a shorter life than INV B, it is possible to repeat this investment more frequently than INV B. This quicker turnaround for INV A is the reason it yields a higher annual return.

The example laid out in Table 2 is representative of the analysis that must be performed when one is trying to decide whether a 13 month calving interval for a dairy cow is more profitable than say an 18 month calving interval. Since decision about calving intervals involves differences in the timing of returns it follows that annuity equivalents should be computed to compare the profitability of these calving options.

A Model For Estimating the Value of Dairy Cow Returns Over Time

Using the discounting techniques illustrated in the previously discussed examples, a valuation model was developed to compute the value of the net returns a dairy producer could earn when the calving interval is set at a specific number of weeks. The following equations are a mathematical expression of this model.

$$(1)\quad AEAR = \frac{-PVI + PVROF - PVOC + PVS}{USPV_{d,(C \bullet L \bullet W)}} \bullet USPV_{d,52} \bullet (1+d)^{52}$$

$$(1a)\ PVI = \sum_{c=1}^{C} I_c \bullet (1+d)^{-([c-1]*[L \bullet W])}$$

$$(1b)\ PVROF = \sum_{c=1}^{C} \Big[\sum_{l=1}^{L} \Big(\sum_{w=1}^{W} ROF_{w,l,c} \bullet (1+d)^{-w} \Big) \bullet (1+d)^{-(W \bullet [l-1])} \Big] \bullet (1+g)^{c-1} \bullet (1+d)^{-([c-1] \bullet [L \bullet W])}$$

$$(1c)\ PVOC = \sum_{c=1}^{C} \Big[\sum_{l=1}^{L} \Big(\sum_{w=1}^{W} OC_{w,l,c} \bullet (1+d)^{-w} \Big) \bullet (1+d)^{-(W \bullet [l-1])} \Big] \bullet (1+d)^{-([c-1] \bullet [L \bullet W])}$$

$$(1d)\ PVS = \sum_{c=1}^{C} S_c \bullet (1+d)^{-([c \bullet [L \bullet W])}$$

$$(1e)\ PVCLF = \sum_{c=1}^{C} \Big[\sum_{l=1}^{L} CLF_{l,c} \bullet (1+d)^{-(l \bullet W)} \Big] \bullet (1+d)^{-([c-1] \bullet [L \bullet W])}$$

Where:

AEAR is the annuity equivalent of the returns from dairy;

PVI ,the present value of the investments in cows;

PVROF, the present value of the milk returns over feed costs;

PVOC ,the present value of the operating costs that are incurred while a cow is milking or in her dry period;

PVS , the present value of the proceeds from the sale of cows for slaughter;

d, the opportunity cost of capital (expressed as a weekly interest rate that is equivalent to a specified annual percentage rate);

C, the number of cows that will be purchased, milked and culled over time;

c, the cow currently being milked;

W, the number of weeks of in a calving interval;

w, the week of a cow's lactation;

L, the number of lactations a cow will complete before it is culled;

l, the lactation of a cow;

$USPV_{\mathbf{d, C \bullet L \bullet W}}$, the uniform series present value factor for a cost of capital of d and a period of C•L•W weeks;

$USPV_{\mathbf{d, 52}}$, the uniform series present value factor for a cost of capital of d and a period of 52 weeks;

I_{c} , the investment cost of cow ***c***;

$ROF_{w,l,c}$, the returns over feed costs for week ***w*** of lactation ***l*** of cow ***c***;

$OC_{w,l,c}$, the operating costs for week ***w*** of lactation ***l*** of cow ***c***;

S_c, the slaughter value of cow ***c***;

$CLF_{l,c}$, the value the calf sold from lactation ***l*** of cow ***c***; and

g, is the rate of growth in returns over feed costs from genetic improvement in cows over time.

For the above model, the annuity equivalent (equation 1) is a function of time, the opportunity cost of capital, and the five present values that are expressed as equations 1a through 1e. The first present value (equation 1a) reflects the investment a dairy producer must make each time a dairy cow is purchased and put into production. The second and third present values (equations 1b and 1c, respectively) reflect the net returns a producer receives when a cow is producing milk. Equation 1b is the value of milk sales over feed costs and equation 1c is the value of all other direct production costs such as bedding, supplies, utilities, labor, etc. The fourth present value (equation 1d) represents the value of the proceeds a producer receives from the sale of a cull cow for slaughter. The last present value of the above model (equation 1e) reflects the value of the proceeds from the sale of calves. Like the annuity equivalent, the present values are a function of the opportunity cost of capital and time.

In the above model time is expressed in terms the number of weeks in a calving interval (W). This time specification determines the timing of returns and costs across a cow's lactations and it also determines the timing of the receipts and expenditures related to the culling and replacement of cows.

A computerized version of the above model was constructed and then used to determine how the value of returns from dairy vary depending on the length of a calving interval. This analysis was performed using various assumptions about milk prices, input costs, milk production over time and other factors. These assumptions are detailed in Appendix 1 of this report.

The values reported in Table 3 are the results that were obtained from the computerized model for calving intervals ranging from 56 weeks (13 months) to 76 weeks (18 months). These values in the right-hand column clearly show that a negative relationship exists between the length of the calving interval and annual returns (annuity equivalent) such that annual returns decrease roughly $30 for each four week extension of the calving interval. Given these results, we can conclude that extending calving intervals is not a recommended action. Rather the reported values suggest that a dairy producer should be attempting to keep the calving interval at or near 56 weeks.

Table 3: **Annual Returns From a Dairy Cow With Various Calving Intervals (CI)**

CI in Weeks (Months)	**Annual Return ($)**	**Difference From Return for 56 Week CI ($)**
56 (13)	959.82	-------
60 (14)	936.78	-23.04
64 (15)	909.65	-50.17
68 (16)	879.49	-80.33
72 (17)	847.13	-112.69
76 (18)	813.19	-146.63

The results reported in Table 3 apply to a specific set of assumptions about a variety of variables. It was recognized that different results could be obtained if some factors such as milk price or milk production are different. To explore this possibility three other analyses were performed to see if extended calving intervals might be advisable under different economic conditions. For one of these analyses the milk price was changed from $13.00 to $14.00 to see if an increase in milk price makes extended calving intervals more desirable. A second analysis was performed to see if an increase in peak daily milk from 100 pounds (base assumption) to 105 pounds makes extended calving intervals more preferable. A third analysis was performed under the assumption that the opportunity cost of capital was 7 percent versus 8 percent as was assumed for all other cases. This latter analysis was conducted to see if extended calving intervals are more preferable when capital costs are at lower levels. The results of these analyses are summarized in table 4.

In all three of the analyses referred to in Table 4, returns were at a maximum when the calving interval was at the minimum level of 56 weeks. This information is noteworthy because it is further evidence that is advantageous for a dairy producer to strive for short calving intervals versus extended ones.

Table 4: Annual Returns From A Dairy Cow For Various Calving Intervals (CI) When There Are Changes in Milk Price, Peak Production per Cow, and the Opportunity Cost of Capital

	Returns ($) for case when:		
CI in Weeks	**milk price is $14 vs. $13.00 per CWT**	**milk production per day is 105 vs. 100 pounds at peak**	**the opportunity cost of capital is 7% vs. 8%**
56	1235.13	1091.00	962.14
60	1209.82	1066.41	939.01
64	1179.98	1037.61	911.80
68	1146.79	1005.69	881.59
72	1111.16	971.51	849.18
76	1073.78	935.71	815.19

Gains From Genetic Improvement and The Length of Calving Intervals

Another factor that needs to be considered when evaluating the profitability of various calving interval options is the genetic improvement that occurs as genetically superior cows are incorporated into a dairy herd over time. This improvement in the productivity of cows is important to producers because the profitability of their operations will rise over time as higher producing cows enter their herds.

How quickly a dairy producer is able to gain the benefits of genetic improvement in part depends on the length of the calving interval for the producer's herd. In general a producer's gain from genetic improvement should be greatest when calving interval is held to a minimum because this management strategy allows for higher producing cows to enter the herd sooner.

To see if shorter calving intervals are indeed preferred when the productivity of cows is rising over time due to genetic improvement, another analysis was performed using the model developed for this study. For this analysis it was assumed that returns over feed costs would grow 1 percent each time a cow was culled and replaced with genetically superior cow. The results of this analysis are reported in Table 5 along with the results that were obtained in the absence of genetic improvement.

Table 5: Annual Returns From A Dairy Cow For Various Calving Intervals (CI) When There Are Gains From Genetic Improvement

CI in Weeks	Returns ($) With 1% Growth In Returns Over Feed Costs Due to Genetic Improvement	Returns ($) With No Growth In Returns Over Feed Costs Due to Genetic Improvement	Gain ($) Due To Genetic Improvement
56	1006.14	959.82	46.18
60	980.93	936.78	44.15
64	951.65	909.65	42.00
68	919.40	879.49	39.91
72	885.01	847.13	37.88
76	849.10	813.19	35.91

The data in Table 5 show two important things. First, as expected, these data show that genetic improvement does result in improved profits for producers. Second, and more importantly, these values show that producers can experience greater gains from genetic improvement when calving intervals are held to a minimum. This point is evidenced by the fact that the gains from genetic improvement reported for the shorter calving intervals are greater than those reported for longer calving intervals. These results are important because they further suggest that shorter calving intervals are preferable to extended ones.

The Desirability Of Extended Calving Intervals When A Cow Is More Persistent In Producing Milk

All of the previously discussed analyses were performed using the same assumption about the pattern of a cow's production over the course of her lactation. It was recognized that with the use of rBST the daily decline in a cow's daily production may not be as great as was assumed in the previous analyses. Therefore, it was decided that it would be appropriate to perform additional analyses to determine how a producer's decisions about calving intervals might change if a cow is more persistent in producing milk over lactation. The results of these analyses are summarized in Table 6.

TABLE 6: Annual Returns ($) From a Dairy Cow For Different Rates of Decline in Daily Milk Production From Day 63 of Production To 76 Days Prior To The Start of the Dry Period

	Daily Rate Of Decline In Milk Production:		
Calving Interval in Weeks	**.1152%**	**.0922%**	**.0691%**
56	1154.95	1225.30	1374.71
60	1151.39	1229.36	1395.95
64	1142.93	1228.34	1411.91
68	1130.6	1223.23	1423.54
72	1115.21	1214.85	1431.61
76	1097.38	1203.80	1436.72

The data presented in each column of the table correspond show how returns vary depending on a cow's persistency in producing milk. High persistency is reflected by the values in the right hand columns and lower persistency in a cow's production is reflected by the values presented in the two left-hand columns.

The values in the far right-hand column of the table are noteworthy because they show that extended calving intervals can be preferable when the daily milk production of a cow declines at a relatively slow rate. In this particular the reported values show that a producer can increase annual returns from about $1350 to roughly $1380 by extending the calving interval from 56 weeks to 76 weeks. Give these results we can conclude that extended calving intervals may be desirable in those cases where a cow's persistency in producing milk is high.

The values in Table 6 indicate that it can be advantageous to extend calving intervals to 72 to 76 weeks when a cow's production declines at a minimal rate over the course of lactation. The question that needs to be asked, however, is whether a cow can actually maintain the level of production across a lactation that is needed to justify an extended calving interval. In the case where the 76-week calving interval yielded the highest return, the daily milk production peaks at about 105 pounds and then declines to roughly 95 pounds on day 305 of milking. This 10 pound decline in daily milk production is considerably less than the decline one normally observes in a cow over the time period in question. The production model that has been used throughout this study suggests that a cow's daily milk production should be expected to decline roughly 37 pounds from a peak of 105 pounds to roughly 68 pounds on day

305 of milking. If this latter pattern of production is representative of the actual production of a cow, it seems highly unlikely a cow could come close to achieving the daily production levels over time that are needed to justify an extended calving interval of 76 weeks. This said it is seems doubtful that a calving interval of 76 could ever be economically justified.

Conclusion

The results of this study that were obtained using net present value capital budgeting techniques consistently show that maximum profits are earned when the calving interval of a dairy cow treated with rBST is held to a minimum. This finding is important to dairy producers because it means they will lose profits if they follow the recommendations of some who are saying extended calving intervals are advisable when cows are treated with rBST. The results of this study clearly show that extended calving intervals are less profitable than calving intervals that are held to the minimum. Given these findings, dairy producers should reconsider any decisions they be contemplating about extending calving intervals because this action will no doubt cause them to lose potential profits.

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APPENDIX 1: **Base Assumptions For The Analysis**

Peak daily milk production at week 8	101.36 lbs.
Milk production over 305 days	26,719.42 lbs.
Daily percent decline in milk production from peak to end of lactation *	0.1844%
Day rBST treatments initiated	63
Frequency of rBST treatments	14 days
Day last rBST treatment given	28 days prior to dry period
Cost of rBST treatment	$6.00
Initial production response from rBST	8 lbs.
Dry period	56 days
Lactation's per animal before culling	3
Cost of replacement	$1400/HD
Slaughter value of cull cow	$450/HD
Value of calf sold	$100/HD
Milk price	$13/CWT

Feed, supply, inputs, labor costs etc. are initially set for a 305 day lactation and then increased on the basis of pounds of milk produced for lactations beyond 305 days

* *The above assumption about the daily decline in milk production and was derived from a lactation yield model appearing in a publication authored by Homan and Wattiaux entitled, Technical Dairy Guide: Lactation and Milking, that was published by the Babcock Institute for International Dairy Research and Development of the University of Wisconsin. This model was modified slightly to account for the production response that can result from rBST treatments. The following figure illustrates the results that are obtained when this modified lactation yield model is used to simulate the milk production of a cow over time.*