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Improving Reproductive Efficiency: What and How That Affects Your Bottom Line

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Introduction

Poor reproductive efficiency is a significant source of economic loss affecting many dairies. Reproductive inefficiency results in economic losses through a variety of ways. Cattle that eventually become pregnant, but at a much later time than desired, spend a disproportionate amount of their lactation at lower levels of milk production, costing the dairy in potential marginal milk. Cows that fail to become pregnant during the breeding period are culled once milk production has declined below economically viable levels, forcing the replacement of an otherwise healthy animal. Historically, dairy managers and consultants have used calving interval or days open as indices for evaluation of reproductive performance and the optimal calving interval for most cows has been considered to be in the range of 12 to 13 months, yielding a lactation length of approximately 10.5 to 11 months. This belief has been supported by other economic models examining the effect of days open and reproductive success on economic returns of dairies.[1-3] However, these assumptions often do not fully consider the transition related culling risk, the potential changes in lactation curve shape of today's modern dairy cow, or the cost associated with cows that fail to become pregnant and thus are removed from the herd.

The use of calving interval or average days open are biased estimates and do not adequately estimate the current status of the majority of cows in the herd. Average days open only gives the interval from calving to conception for cows that have successfully conceived and gives no information regarding the status of the non-pregnant animals other than potentially their current days in lactation. Calving interval is even more limited in that it only considers the cows that became pregnant and maintained that pregnancy throughout a full gestation. Pregnancy rate (**PR**), defined as the proportion of eligible cows that became pregnant each 21 day cycle and examined over a sequence of 21-d cycles, is the preferred parameter for evaluating reproductive performance. It is more sensitive to detecting recent changes in reproductive performance and provides useful information since both pregnant and non pregnant cows that meet the eligibility criteria are considered in the calculation.[4] Based on database surveys as reported by Steve Stewart, Bruce Clark, Don Niles, Stephen LeBlanc and David Galligan (personal communications), PR in the U.S and Canada appears to average between 14-16%. Yet, many dairy advisors consider a PR of 25-30% to be the ultimate goal for optimum reproductive management.

With the large difference between the average PR and the goal for PR, there is significant room for improvement. There are many ways of improving herd reproductive efficiency and many non-breeding factors that dramatically influence reproductive outcomes, but essentially it comes down to improving insemination risk (IR), conception risk (CR), or preferably, both. The objective of this paper is to explore the potential value generated as a result of improving PR via a variety of methods and to examine the various drivers of economic returns associated with changes in PR, as well as illustrating how much a dairy may be able to spend in order to try and achieve an improved PR.

Model Building and Assumptions

The original model was built using Excel® spreadsheets and @RISK® simulation software and has been modified numerous times in order to refine it and to examine new factors. Distributions describing CR and IR (almost exclusively from estrus detection) were fit from data obtained from approximately 95 herds representing approximately 150,000 cows (Niles, et al. and other California dairy herds) and are used to mimic the normal variation seen between and within dairies. Daily milk and 305 day mature equivalent milk production estimates were also obtained from a variety of dairies and used to fit lactation persistency curves based on day in milk (**DIM**). Milk price estimates, cull cow values, market cow values, labor estimates, and other key inputs were derived from either published work or adapted from actual herd data. Culling risks over the entire lactation period were obtained from actual herd Dairy Comp 305 records and mathematically adjusted from 30-day to 21-day intervals to be consistent with the breeding cycles.

All values of change in PR are obtained by comparison with a baseline program. The baseline breeding program is a simple estrus detection-based reproductive program with CR and IR distributions at each 21-day interval following a 50-day voluntary waiting period. The potential breeding period is 12 21-day cycles for a total of 252 days of breeding. In other words, cows are eligible for breeding from 50 days in milk until 302 days in milk. Simulated PR's are obtained by multiplying randomly generated samples from the CR distribution and IR distribution. The user can manipulate the baseline PR by applying a multiplier to the sampled CR, IR or both, throughout the program, resulting in the desired PR for comparison.

There are 3 breeding programs for comparison. The first is called an "improved baseline program" (**IBP**). This program is designed to mimic the changes that may be obtained as a consequence of improving CR, IR or both over the course of the breeding period. No synchronization programs are included in this program. This particular program was designed to estimate the value that may be obtained by simply doing a better job with a traditional estrus detection-based program.

The second program that is used for comparison is a total timed AI program (**TAI**) and is based upon a Presync-Ovsynch with day-32 Resynch. Briefly, this program includes an injection of prostaglandin F2α at 36+/- 3 days in milk, followed in 14 days with a second injection. After an additional 14 days, cows received an injection of GnRH to start the Ovsynch portion. In 7 days, another prostaglandin is given, followed in 56 hours with the final GnRH injection and a timed insemination 12-16 hours later. No estrus detection is used. All cows are given an injection of GnRH at 32 days post-breeding. In 7 days, cows are examined via palpation per rectum and non-pregnant animals are given a prostaglandin injection and then proceed to complete the Resynch (Ovsynch) portion of the TAI. Following this schedule, all non-pregnant cows are re-inseminated every 42 days until the breeding period is concluded.

The final program for comparison is a combination of estrus detection and TAI and is referred to as the modified Presynch program (**MPS**). Cows that follow this protocol receive two prostaglandin injections at 14-day intervals starting at 36+/- 3 days in milk. Cows that are observed in estrus after the second injection are inseminated per normal farm routine. Cows that are not observed within 14 days start the Ovsynch program as previously described. Afterwards, all inseminations for the remainder of the breeding period is performed using estrus detection. Thus, the second breeding cycle is composed of two groups of cows - those that are inseminated via estrus detection and those that are inseminated by TAI, depending upon whether estrus was detected in the first 21 days following Presynch or not.

In both the TAI and the MPS program, all cows are assumed to incur the cost of the injections, as per the schedule, but due to less than perfect on-farm compliance, only 85-90% of cows initially enrolled are actually inseminated, depending on the compliance factor input into the model. The CR for each of these two programs is modeled as a function of the farm's baseline conception risk, the estimated proportion of cows that are truly cycling, expected distribution within the estrous cycle at the start of the program, and published reports involving TAI.[5-11]

The pregnancy rate from traditional breeding is obtained by taking the product of random samples from CR and IR for each cycle. All cycles are exactly 21 days long, all cows calve at the same time, and they are followed prospectively. There was no attempt to model the impact of abortion or seasonal effects on reproduction except as demonstrated by the impact from the original data set on CR and IR distributions. (It is assumed that CR results used in the model already reflect some of the expected embryonic deaths since most herds are not palpated for pregnancy until approximately 40 days post-insemination and most of the embryonic wastage occurs by 45-50 days.) Timed AI programs are assumed to have no effect on subsequent conception or estrus detection risk in non-pregnant cows and it is assumed that there are no differences in reproductive efficiency for any of the programs between parities of lactating cows, i.e., the results are expressed for the blended population on a per cow slot basis. The voluntary waiting period is 50 days and as cows move from the first cycle to the second, the proportion of cows expected to be cycling increases (the model decreases the proportion that are anestrus by 33% of the original proportion). Cows are palpated for pregnancy at approximately 39+/- 3 days post-breeding. Milk production, price of milk, and other economic values remain the same throughout the year. Milk production level may be utilized as a discrete variable to determine the impact at a certain 305ME milk production level, or stochastically (sampled from a distributions) to determine the average impact (and expected range of impacts) over many dairies.

Reproductive performance across the 3 alternative breeding approaches are then compared to the original baseline program. Herd specific data that may influence on-farm profitability, including dry period length, calf death losses, culling risk across time, milk production, milk price, pharmaceutical costs, labor costs, and feed costs are entered. The model's inputs, herd-specific data, and pre-set distributions are linked to tables for each reproductive intervention and are used to estimate the average pregnancy rate over 252 days of potential breeding. The input table, herd-specific data, and pregnancy rate projections are linked to partial budgets (modifications of original work by Wolf and Dartt) to compare predicted economic returns resulting from changes in daily milk yield as a result of changes in reproductive performance.[12] Cows that are ultimately culled as non-pregnant, but that are milked successfully until then, are removed from the dairy at 600 to 750 days in milk. Stochastic modeling with @RISK® simulation software utilizes Monte Carlo sampling of the pre-set distributions and runs 1000 iterations. Results are then displayed as probability distributions, with a mean and 90% confidence interval.

Annual herd turnover or culling risk may be dramatically impacted by changes in reproductive performance. Herds that get more cows pregnant have fewer cows that must be removed due to a failure to become pregnant. However, these same herds are also producing more female calves, and assuming proportional mortality risk across time, will have more replacement animals available to either sell, expand the herd, or replace a less profitable animal in the herd. If the latter option is chosen, the herd's culling risk will increase. In the model, all calves are sold as newborn calves and purchased back as needed. When reproductive performance improves, there are fewer cows that are forcibly removed due to reproductive failure. Consequently, the herd's apparent culling risk decreases. However, in the model, I assumed that the dairy would save on involuntary culling by retaining cows equal in number to one half of the increased number of pregnancies accrued. The other half would allow the dairy to cull some poor producers from the herd. As a consequence, the herd's culling risk would change as a consequence of the changes in reproductive performance.

The economic value of the change in PR is estimated by use of simple partial budgeting approaches. Each new program is compared to the baseline program by transferring the various outputs into its own partial budget. The sources of revenue include predicted milk per cow per day over a year (as determined by the modeled herd's estimated average days in milk and the herd's lactation curve), the annualized value of the calves produced, and the annualized value of the culled cows. Subtracted from the revenues are a variety of expenses that include any additional replacement costs, the marginal feed consumed by cows to produce the marginal milk, additional feed consumed by additional non-lactating cows, the additional costs for housing, labor, and medical expenses, as well as any additional costs due to the change in reproductive management approach. Finally, the difference is adjusted for the time value of money. Since money received in the future is worth less than money received today, future returns have to be adjusted for when the returns actually occur. All of the revenues and expenses, and thus the net returns, are reported as dollars gained (or lost) per lactating cow slot on the dairy per year.

Results and Conclusions

The predicted results of 1000 model iterations comparing the benefits of improving PR by increasing IR by 10% (though improved estrus detection) over baseline are shown below in figure 1. The starting average PR was 15.9% and the improved program's PR was approximately 17.6%.

Figure 1. Distribution of PR outcomes for improved program as a consequence of improving insemination risk (in this case, estrus detection) by 10% as compared to the baseline program.

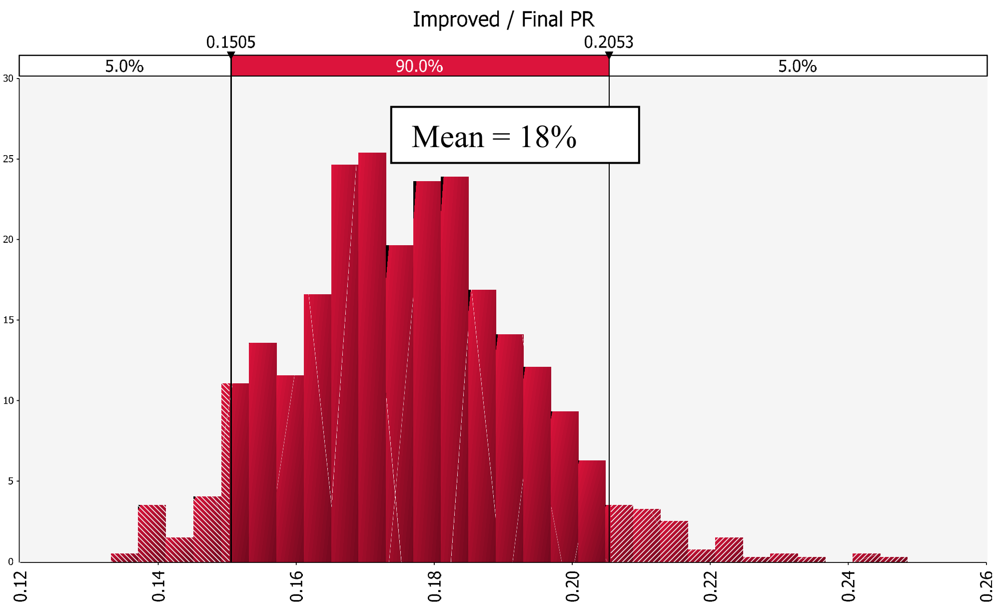
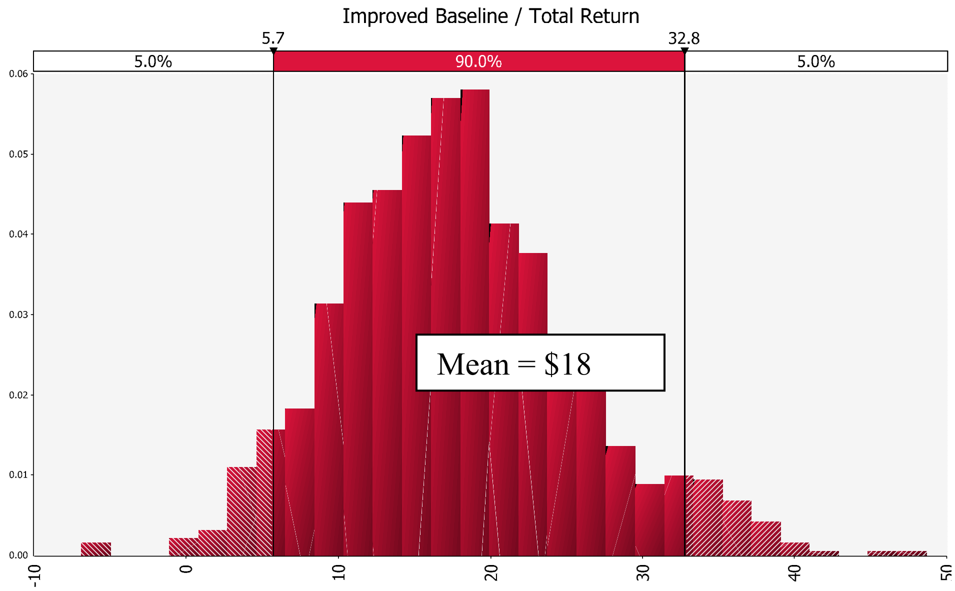


Figure 2 displays the predicted economic value of the PR improvement (average of 1.7 units of PR change) over 1000 iterations. These results were taken from the fully stochastic model with the following input distributions (and their expected or average value): milk price ($12), CR (30%), IR (57%), herd level of milk production (23,000 lbs), market cow value ($621), replacement heifer cost ($1700), heifer calf ($250) and bull calf ($15). Overall, the improvement in IR resulted in a net of $11 per unit change in PR, or a total return of approximately $18 per cow slot per year.

Figure 2. Distribution of Predicted Returns per Unit Change in PR As a Consequence of Improving Insemination Risk by 10% (Mean = $18)



As mentioned previously, the model also allows for comparison of different approaches to improving reproductive efficiency. Each of these new approaches is compared back to the original baseline program to estimate the value of the change after also considering the cost of implementing the new programs. The results are shown below in figure 3. Each program is expected to yield an improved PR but the magnitude of the improvement and the value of the change is different for each one.

First, the improved baseline shows a similar result as above with the new PR of 17.5% which is predicted to yield a value of about $18 per cow slot per year as a result of the improved insemination risk.

The total TAI approach also yields an improved PR but the apparent increase is minor relative to the other approaches, but a word of caution is due here. Total TAI, as modeled in this scenario, yields a PR of almost 19% when using a VWP of 70 days (when the breeding actually starts) but for comparison sake, I maintained the same VWP as the other programs of 50 days. Hence, the lower than expected PR of only 16.3% is due in large part to the lack of breeding during the first potential cycle at 50-70 DIM. These non-breeding days are used to presynchronize cows, yielding an improved CR. However, it comes at the cost of a delay to first service. Despite the increased cost of this approach, there is still a positive return of about $15.

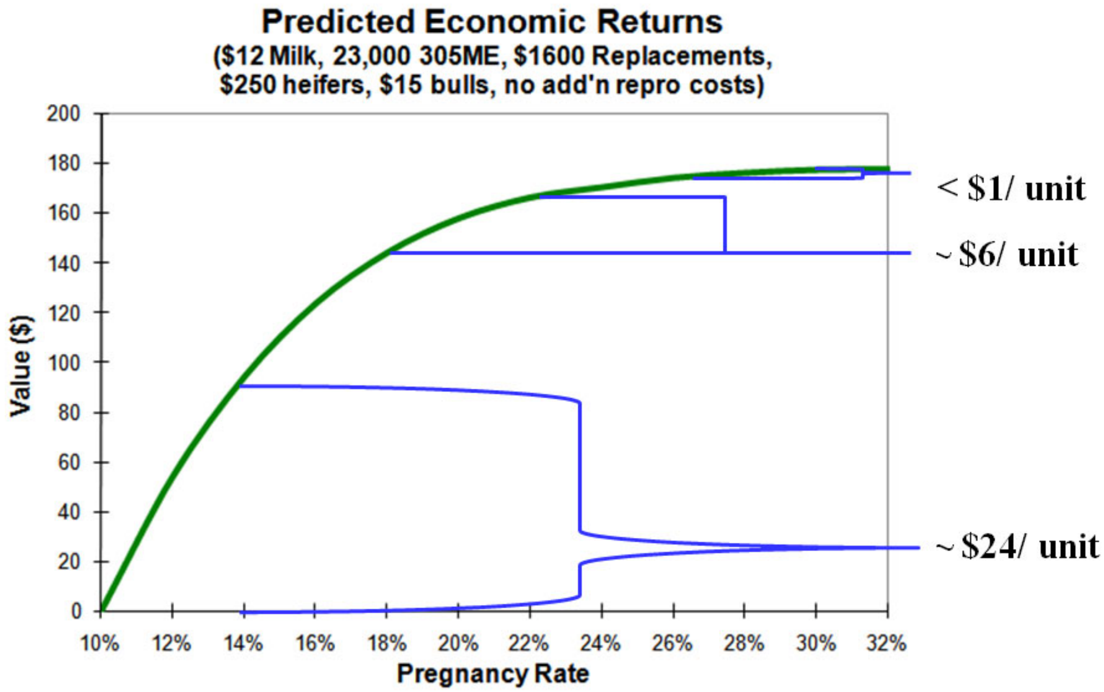
The final approach was the backdoor Ovsynch which included a Presynch series for all cows followed by a one-time use of Ovsynch only for cows that failed to be inseminated via estrus detection in the first cycle. This program incurs a larger cost with a lower rate of return as compared to the others, but is still an improvement compared to the baseline. The expected value of this approach would be greater had the program continued with additional Ovsynch-based breedings in later cycles. However, this hybrid approach was not modeled in this set of iterations.

Figure 3. Estimated results and associated values of three different approaches to improving reproductive performance as compared to the baseline program.

	Final PR	# preg	Cost/ preg	Preg Rate Improvement	Return
Baseline	15.9%	755	$64.09	--	
Improved Baseline	17.5%	779	$71.32	1.7%	$18.02
Total TAI	16.3%	776	$72.62	0.4%	$15.25
Backdoor PS-OS	17.8%	773	$74.05	2.0%	$5.90

Figure 4 below illustrates a very important concept to remember when evaluating the economic returns of improving reproductive performance – predicted returns follow a curvilinear relationship. In other words, the average return associated with improving PR varies depending upon the relative success of the starting point. In this series of scenarios, I calculated the predicted returns of increasing PR starting at a 10% baseline PR. The baseline PR of 10% was compared to improved PR across a range of values, derived by changing the CR and IR. At 10% PR, the value of improving PR by 2 unit (ie. 10% to 12% PR) is predicted to be worth approximately $54 per cow slot per year when milk was valued at $12/ cwt. Conversely, going from 18 to 20% is worth approximately $14 and from 26 to 28% is worth only $2.

Figure 4. Model Results of Value of Changes in PR over Ranges of PR



One of the benefits of using stochastic simulation models is the ability to perform sensitivity analyses of the major effect modifiers. Within the distributional ranges used in the model, the following variables had the largest impact on the economic value associated with reproductive performance change and each of the variables is listed in descending order of impact: 1) Insemination risk – As insemination risk increased in the baseline model, the value of the change decreased. In other words, if the starting reproductive performance was high, there was less to be gained from further improvements. 2) Conception risk – As conception risk increased in the baseline model, the value of the change decreased just as with insemination risk. 3) Milk price – As milk price increased, the predicted value of the change in reproductive performance increased. 4) Feed cost – As feed cost increased, the value of change decreased due to the reduced profit margin associated with the marginal milk produced. 5) Level of milk production – As the herd level of milk production increased, the predicted value due to improving reproductive performance increased. 6) Replacement cost – As the price for replacement heifers increased, the value realized by improving reproductive performance increased. 7) Market cow price – As the value of the market cow increased, the value realized by improving reproductive performance decreased.

The primary economic driver is the value of the additional marginal milk produced as a consequence of improving reproductive performance. Figure 5 demonstrates the impact that milk price may have on the economic returns. For this example, each of the following inputs was entered as specific values and the only one to vary was the price of milk: herd level of milk production = 25,000 lbs, market cow value = $0.46/ lb, replacement heifer cost = $1600, TMR cost = $210, heifer calf = $250 and bull calf = $15. For this set of scenarios, a 50-day voluntary waiting period was used and other than additional semen and insemination fees associated with an increased insemination risk, no additional reproductive management costs were assumed. As the value of milk increases, the value of the reproductive change increases within a range of PR change. For example, at $14 milk, increasing PR from 18% to 20% is predicted to yield an economic return of approximately $24 per cow slot or roughly about $12/ unit change in PR/ per cow slot per year.

Figure 5. The Impact of Milk Price on Economic Returns of Improving PR

Crude Value of Incremental Changes in PR at Varying Milk Price

		Milk Price				
		$10	**$12**	**$14**	**$16**	**$18**
PR	**14%**	referent	referent	referent	referent	referent
	16%	$27	$36	$45	$54	$64
	18%	$19	$26	$33	$41	$48
	20%	$13	$19	$24	$29	$35
	22%	$8	$12	$16	$20	$24
	24%	$5	$8	$11	$14	$17
	26%	$4	$7	$10	$12	$15

The concept of diminishing returns is nothing new. We see similar patterns in many biological systems. In the case of reproductive management, one must keep this issue in mind relative to making recommendations to clients. Herds that are already doing a good job reproductively have less potential economic value to be gained by improving performance even further. Likewise, if a herd's performance is already good with a baseline breeding program, one should carefully consider whether additional input costs will legitimately improve PR and return a profit to the dairy. In general, herds should work to improve basic semen handling and estrus detection prior to jumping on a TAI program. Other management issues such as compliance to protocol are also critical to the success of any program.

Most herds have much to gain by improving reproductive performance. Improving PR results in higher milk production, more pregnant cows, more calves, and reduced reproductive-based culling. Sensitivity analyses of model results reveal that insemination intensity, whether by estrus detection, timed AI or a combination, has the largest impact on reproductive performance. Efforts at improving reproductive success should first focus on maximizing the herd's basic estrus detection efficiency, due to its large impact on reproductive success and because it is more easily improved as compared to conception rate. Herds with very poor reductive efficiency have the most to gain by improving PR, and within a given level of PR, the price of milk has the greatest effect on the value of the economic change, followed by the herd’s level of milk production. Consequently, our emphasis in reproductive management should continue to be placed on improving insemination risk while at least maintaining conception risk. Although almost any herd can potentially benefit from synchronization programs, herds with poor reproductive performance are expected to realize the greatest potential return from improving reproductive performance, especially those herds with higher levels of milk production.

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