Financial Feasibility of Embryo Transfer

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Introduction

Embryo transfer technology has been used as a laboratory technique since the late 1800's, but it was not used commercially until recently. The advent of exotic breeds of cattle in the 1970's provided the economic incentives for application of the technology for commercial purposes (1).

Previous economic studies have indicated that the cost per calf may be as high as $2,414 (1) or as low as $200 as reported in a popular source (2). Van Vleck has stated that increased milk production will not pay for the extra costs of embryo transfer (3). This conclusion was based on the net present value of the additional milk after taking into consideration the genetic potential of the dam and sire. Another study estimated that for milk receipts alone to pay for the added cost, the cost of embryo transfer would have to drop to below $200 per pregnancy (4).

Predictions for the future of embryo transfer range from optimistic (5) to the cautious (1). The cautious note that the basic motivation for present use of the technology is not increased milk production, but tax incentive exploitation by livestock breeders and investors. None of these previous studies have presented the financial feasibility along with the tax benefits.

Tax incentives from embryo transfer are very attractive and often entice investors in the high marginal tax brackets into the industry. Investors as well as livestock breeders can take advantage of investment tax credit, depreciation, capital gains and can expense the costs of embryo transfer under the Internal Revenue Tax Codes (6).

The objectives of this paper are to: (1) determine the feasibility of embryo transfer including tax benefits and (2) to determine by sensitivity analysis some conditions under which it becomes feasible.

Method

On-farm embryo transfer is considered in this article. The analysis is based on the marginal (incremental) costs of embryo transfer from donor to recipients over costs resulting from artificial insemination by a superior sire where the cow carries her own embryo. The on-farm technique was selected because the technology is available and it is being done successfully. Since it is both the low-cost and low-risk method it sets the base standard for comparison. If this method is not economically viable the use of higher cost alternatives would not be feasible.

The model was developed on a CALC RESULT spreadsheet using a Commodore 8096 microcomputer. All of the parameters in the model were included as variables so they could be changed for the sensitivity analyses. Sensitivity analyses were done by changing key variables and determining the impact on the cash flow and net present values.

The net present value is defined as

$$NPV = \sum_{i=1}^{N} \frac{B_i}{(1 + r)^i}$$

where:

B_i = The net cash flow after taxes
r = Cost of capital or target return on investment for the farm or firm
N = Number of years

Included in the B_is are all of the cash inflows and outflows including the tax incentive indentified above. If the NPV > 0 then the project has a return greater than the target return or acceptable return on investment and the project is feasible. When the NPV < 0 then the project has an unsatisfactory return. A NPV = 0 indicates that the return is exactly equal to the cost of capital.

Alternatives Evaluated

The two alternatives considered were (1) using the top cows in a dairyman's own herd or (2) purchasing top quality cows and using them as donors. Embryo transfer technology would potentially allow a dairyman to select daughters from the top 10 percent of the herd as replacements rather than the top 90 percent, thus improving the genetic potential of the herd more rapidly (3).

Assumptions

Assumptions for the alternatives where donors from the top ten percent of the herd would be used are shown in Table 1. The model is robust enough so that any of these parameters can be changed and the impact determined. Corresponding assumptions for the buy scenario are also shown in this table with only the changes indicated.

Other assumptions are:

1. All bull calves are sold.
2. The model is defined to include all flushes that are completed within one year. If the process is profitable for this period, it will be profitable for repeated replications.

TABLE 1. Assumptions for base cases, 1983.

Assumptions	Value Owned Donor	Value Purchased Donor
Milk Price and Production		
Milk Price/Cwt.	12.00	
Milk Production Donor -Lbs/305 days Mature Equivalent	27,000	30,000
Milk Production Recipient -Lbs/305 Days Mature Equivalent	17,000	
Milk Production Offspring -Lbs/305 Days Mature Equivalent	20,000	21,000
Milk Production by Lactation as Percent of Mature Equivalent		
Lactation 1	0.77	
Lactation 2	.087	
Lactation 3	.094	
Lactation 4	0.98	
Lactation 5	1.00	
Lactation When Donor is Flushed	5	
Lactation of Recipients After Having Donor's Calves	1	
Animal Purchase and Sales Information		
Heifers- Additional Value Above Recipient Calf at Any Age	2,000	
Bulls- Additional Value above Recipient Calf at Any Age	100	
Number of Heifers Sold	1	
Purchase Price of Donor (Time 0)	0	15,000
Sales Price of Donor (Time 1)	0	13,000
Operating Costs		
Synchronization Drugs per Recipient and Donor per Flush	15	
Semen per Flush	150	
Blood Typing of Donor	30	
Blood Typing per Calf	30	
Embryo Transfer Flush Fee per Flush	100	
Embryo Transfer Fee per Pregnancy per Flush	250	
Registration Fee per Calf	30	
Veterinary Cost per Recipient	0	
Extra Labor (Hours per Flush)	4	
Extra Labor Cost per Hour	4	
Administrative	100	
Feed Costs		
Feed Costs per Cwt of Milk	6.50	
Percentage of Cow's Feed Requirements Used to Produce Milk	0.65	
Feed Costs per Day for Dry Cows or Heifers	1.25	
Recipient Feed Costs/Day	1.25	
Technical Assumptions		
Implantable Embryos per Flush for Cows Receptive to Treatment	4	
Number of Flushes per Year	2	
Conception Rate	0.65	
Loss of Production by Donor (%)	0.15	
Number of Recipients/Flush	8	
Calf Loss Percentage	0.10	
Percentage of Heifers	0.50	
Percentage of Bulls	0.50	
Delay in Recipient Milk Production (Days)	20	
Percentage of Heifer Calves Entering Milking Herd	.70	
Loan Information		
Amount Borrowed for Donor (Principal)	0	10,000
Interest Rate on Principal	0.00	.13
Term of Loan in Years	0	5
Capital Expenditures		
Equipment	0	
Buildings	0	
Tax Information		
Investment Tax Credit %	0.10	
Marginal Tax Rate Year 0	0.25	
Year 1	0.25	
Year 2	0.25	
Year 3	0.25	
Year 4	0.25	
Year 5	0.25	
Depreciation		
Year 1	0.15	
Year 2	0.22	
Year 3	0.21	
Year 4	0.21	
Year 5	0.21	
Discount and Inflation Assumptions		
Cost of Capital or Target Return on Investment	0.07	
Inflation Rate	0.05	

3. For the buy scenario, it was assumed that the animal was sold after one year even though this may not be the usual nor expected procedure. Necessary adjustments were made to the cash flow after considering the tax implications.

It was assumed that the herd has a 365 day rolling average of 17,000 lbs of milk. The donors would have had four lactations with mature equivalents significantly above the herd average. Milk production of the daughters of these donor cows and their superior mates would be expected to be above the average of the recipients. The extent of the difference will depend on the selection differential. It was assumed that the major share of the costs of embryo transfer will be paid for by the sale of one of the heifers and a slight

increase in value of male calves. The increase in milk production from the donor's offspring is partially offset by loss in donor milk production and extra feed costs resulting from delaying recipients. Specific costs of stimulating and collecting embryos are shown in Table 1.

Implantable embryos obtainable from cows which will successfully superovulate vary from four to five as reported by Donaldson (7). The delay in recipient milk production is an average. Those recipients who conceive will not be delayed usually. The recipients who fail to conceive will be delayed longer than those who are extra and are not given embryos. The percentage of heifer calves entering the milking herd is determined by calf survival, heifer infertility, and abortions.

Results

Base Case for Owned Cow

The base case for an owned cow is unfavorable using the assumptions presented in Table 1. The net present value of $340 indicates that the return is less than the seven percent after tax target return on investment. This return would approximate current money market rates and is very conservative since it doesn't provide a return for risk. A higher return would be required to compensate for more risk and it would make the results less attractive than shown here. (Table 2).

During Year 0, the embryo transfer costs make the net after tax cash flow negative, but there are tax savings which reduce the size of the outflow. The cash flow is positive during the second year due to the sale of the heifer and bull calves. In Year 3, milk receipts from the cows originating as transferred embryos start and the reduction of milk receipts lost by delaying the freshening date of recipients is recoverd. However, the inflows are not large enough to offset the up front costs of the embryo transfer. The additional costs incurred with the transfer calf over an artificial insemination replacement heifer is $452 before and $403 after tax considerations.

Base Case for Purchased Cow

The scenario where a top quality donor is purchased is shown in Table 3. If a donor is purchased for $15,000 and then could be sold for $13,000 at the end of one year and flushed twice, the return is unsatisfactory when the sales price for a heifer calf is $2,000. For this case, the NPV is -$2,725. The additional before-tax cost per calf is $677 and the after-tax cost is $497.

It is possible that the bull calves from a cow of this value could be sold for higher prices than assumed. The cow could also be flushed more than twice per year which would make more offspring available for sale to offset the costs. Table 4 shows the necessary value of the heifer calf sold at different values of bull calves to obtain the target return.

Sensitivity Analysis

Sensitivity analysis was done to determine the relationship between the mature equivalent production differential and the price of bull and heifer calves which would be necessary to obtain a satisfactory after-tax return on investment (Table 4). The production differential is the additional milk which would be expected from the offspring of the donor as compared to the recipient's calf. All other assumptions for the base case were unchanged for this analysis.

With no change in the production differential, the additional value of the heifer calf, which is sold, over a heifer calf from a recipient, must be $2,742 for the owned cow scenario and $6,455 for the purchased cow scenario to meet return on investment guidelines. These values could also be affected by changes in the other technical or economic assumptions.

The impact of the production differential is not great as suggested by earlier studies. In general, the value of increasing the production differential from 0 to 6,000 pounds is approximately $442 or $7.36 per cwt. for both scenarios for each lactation per animal. If Van Vleck is correct in that the expected genetic improvement over artificial insemination is only 76 pounds per year (3), then the value is only minimal for the three lactations assumed. This increase is hardly enough to justify the costs even after considering tax benefits which were excluded in previous studies. This reemphasizes the necessity of obtaining attractive heifer and bull prices to offset the embryo transfer costs.

As the sales price for bull calves increases from $100 to $1,000, a corresponding reduction in the necessary price for heifers occurs. The impact of the decrease is substantial since all of the bull calves are assumed to be sold. If the potential of selling bull calves for high values exists, it has a substantial favorable impact on the return.

No attempt has been made in this study to quantify the impact of the increased value in quality of heifers resulting from transferred embryos. Very likely their added value over replacement heifers coming from a grade recipient could offset some of the costs of embryo transfer.

Upside Potential

Upside potential can be examined in a number of ways. For example, one could assume that higher prices could be obtained from animal sales. If this would happen, the NPV would increase correspondingly. However, an upside on technical assumptions was examined rather than economic assumptions.

An upside could occur if a larger number of embryos were obtained on a given flush and more heifer calves were available for sale. This information is shown in Table 5. If only one heifer is sold the price for a heifer necessary to obtain a substantial return increases as the number of embryos increases. This is because the milk production

TABLE 2. Cash flow and net present values for base case of owned cow scenario.

Item		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Inflows							
Milk Sales (Net of Feed Costs)							
Donor		0	—315	0	0	0	0
Recipients		0	—447	0	629	0	0
Embryo Animals	2.34	0	0	0	81	92	99
Animal Sales							
Recipients		0	0	0	0	0	0
Embryo Heifers		0	2000	0	0	0	0
Embryo Bulls	2.34	0	234	0	0	0	0
Donor Sales		0	0	0	0	0	0
Total Inflows		0	1472	0	710	92	99
Outflows							
Variable Expenses							
Synchronization Drugs		270	0	0	0	0	0
Semen		300	0	0	0	0	0
Blood Typing of Donor		30	0	0	0	0	0
Blood Typing of Calves		0	140	0	0	0	0
Embryo Transfer Flush Fee		200	0	0	0	0	0
Embryo Transfer Fee		1300	0	0	0	0	0
Registration Fee		0	140	0	0	0	0
Veterinary Cost for Recipients		0	0	0	0	0	0
Labor Costs		32	0	0	0	0	0
Recipient Feed Costs		0	0	0	0	0	0
Administrative		0	200	0	0	0	0
Fixed Expenses							
Property Taxes		0	0	0	0	0	0
Repairs and Maintenance		0	0	0	0	0	0
Interest		0	0	0	0	0	0
Principal		0	0	0	0	0	0
Taxes		—533	248	0	178	23	25
Capital							
Buildings and Equipment		0	0	0	0	0	0
Donor Downpayment		0	0	0	0	0	0
Total Outflows		1599	729	0	178	23	25
Net Cash Flow After Taxes		—1599	743	0	533	69	74
Net Cash Flow with Inflation		—1599	780	0	617	83	95

NPV	—340
NPV with Inflation	—220
IRR	Negative
Before Tax Cash Cost per Calf	452
After Tax Cash Cost per Calf	403

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TABLE 3. Cash flow and net present values for base case of purchased cow scenario.

Item		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Inflows							
Milk Sales (Net of Feed Costs)							
Donor		0	—350	0	0	0	0
Recipients		0	—447	0	629	0	0
Embryo Animals	2.34	0	0	0	108	122	132
Animal Sales							
Recipients		0	0	0	0	0	0
Embryo Heifers		0	2000	0	0	0	0
Embryo Bulls	2.34	0	234	0	0	0	0
Donor Sales		0	13000	0	0	0	0
Total Inflows		0	14437	0	737	122	132
Outflows							
Variable Expenses							
Synchronization Drugs		270	0	0	0	0	0
Semen		300	0	0	0	0	0
Blood Typing of Donor		30	0	0	0	0	0
Blood Typin of Calves		0	140	0	0	0	0
Embryo Transfer Flush Fee		200	0	0	0	0	0
Embryo Transfer Fee		1300	0	0	0	0	0
Registration Fee		0	140	0	0	0	0
Veterinary Cost for Recipients		0	0	0	0	0	0
Labor Costs		32	0	0	0	0	0
Recipient Feed Costs		0	0	0	0	0	0
Administrative		0	200	0	0	0	0
Fixed Expenses							
Property Taxes		0	0	0	0	0	0
Repairs and Maintenance		0	0	0	0	0	0
Interest		0	1300	0	0	0	0
Principal		0	10000	0	0	0	0
Taxes		—2539	1495	0	184	31	33
Capital							
Buildings and Equipment		0	0	0	0	0	0
Donor Downpayment		5000	0	0	0	0	0
Total Outflows		4593	13276	0	184	31	33
Net Cash Flow After Taxes		—4593	1161	0	553	92	99
Net Cash Flow with Inflation		—4593	1219	0	640	111	126
NPV		—2725					
NPV with Inflation		—2576					
IRR		Negative					
Before Tax Cash Cost per Calf		677					
After Tax Cash Cost per Calf		497					

differential doesn't pay for the costs. The results are substantially more favorable for both scenarios when two heifers are sold. It would be even more favorable if three or more were sold if that many were available. If a combination of favorable economic and technical factors occurs the attractiveness would be even greater.

Downside Risk

Using a technique of this kind has some downside risk associated with it in case economic or technical factors are not favorable. Suppose that:

1. Only 1 embryo is obtained and it is a bull and consequently there is no increase in milk production from the offspring.
2. The conception rate falls to 50 percent.
3. The recipients are delayed 40 days.

This scenario should represent among the worst of outcomes. In this situation, the net present value is a -$625. This does not represent a substantial loss for an investor or owner. For some people, the magnitude of the upside

TABLE 4. Additional value from sale of heifer calves needed to meet return on investment criterion.

Additional Value of Bulls	M. E. Milk Production Differential	Heifer Price[a] Owned Donor	Heifer Price[a] Purchased Donor
100	0	2,742	6,455
	500	2,704	6,420
	1,000	2,667	6,382
	4,000	2,446	6,160
	6,000	2,299	6,013
500	0	1,805	5,520
	500	1,768	5,480
	1,000	1,731	5,445
	2,000	1,657	5,370
	4,000	1,510	5,225
	6,000	1,363	5,080
1,000	0	635	4,350
	500	600	4,310
	1,000	561	4,275
	2,000	487	4,203
	4,000	340	4,055
	6,000	193	3,905

[a]Heifer price necessary to obtain 7% after-tax return on investment.

TABLE 5. Impact of larger number of embryos and heifer price necessary to meet return on investment criterion.

Embryos/Flush	Heifers Number Sold Per Year 1 Sold	2 Sold
Owned Cow		
3	2,300	—
5	2,735	1,542
7	3,170	1,760
9	3,608	1,978
11	4,043	2,195
Purchased Cow		
3	5,990	—
5	6,330	3,395
7	6,670	3,565
9	7,010	3,735
11	7,350	3,905

potential may offset this downside risk. If someone is not risk averse, the gamble may be a good one if the assumptions for the base case are realistic. If offspring can be sold at attractive prices, a breeder or investor stands to gain more than he could lose even with a rather dismal situation.

Summary

It is interesting to contemplate the future of embryo transfer in the dairy industry since the increase in milk production and tax advantages will not offset the costs. Possibilities which could favorably affect the utilization of these techniques are (1) technological improvements, (2) increases in the value of milk or animals and (3) decreases in the costs of embryo transfer.

Technological advances which could be a stimulus to this technique include better herd management techniques, cryopreservation of embryos and estrus synchronization. Utilization of each of these could reduce the costs and increase the profitability of using embryo transfer on the farm. Cryopreservation is one technology that could have a favorable impact on the industry by eliminating the costs associated with synchronizing estrus in a large number of animals. Technological advances in the other areas could also have favorable impact on the cost structure and profitability.

Intangible benefits accruing from replacing grade heifers with registered heifers have not been examined in this model but would, of course, affect many dairymen in their decisions. The difference between sale value of registered heifers and grade heifers fluctuates but is an economic factor which could favorably influence practices involving embryo transfer.

The milk production differential is not large enough to offset the costs of embryo transfer at current milk prices. The current surplus of dairy products with the corresponding downward pressure on prices leaves little hope that milk prices will increase by an amount sufficient to make the technology attractive. It is only remotely possible that technology will advance far enough so that it will establish profitability based only on increased milk production.

The near term future of the industry will be based on the ability to sell high quality livestock at premium prices. Sales of high quality offspring will continue to provide the economic justification for the use of embryo transfer technology in the dairy industry. Even the most optimistic scenario based on technical assumptions is not feasible if premium prices cannot be obtained.

It is expected that breeders with top quality animals will continue to use this technique to increase the number of saleable offspring from their animals. It is highly unlikely that dairymen who can't sell high priced animals will use it on a widespread basis until the increase in milk production will pay for the costs and provide a satisfactory return on investment.

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