Technology: Price Tag and Profit

Barry H. Dunn
King Ranch Institute for Ranch Management
Texas A&M University-Kingsville, Kingsville, TX 68363-8202

Introduction

In a world that includes the robotic exploration of distant planets, cattlemen may choose to rope calves with lariats in order to implant them with hormones or computer identification chips. As the same calves are branded with a hot iron that has been used as identification for centuries, they may be ear tagged with an insecticide tag and vaccinated against one or several diseases. The choices of available technologies for cattlemen are too numerous to mention. Application rates of available technologies vary greatly between and within industry segments. Cost benefit analysis has long been used as the major tool of evaluation and promotion of the economic benefits of technologies for beef cattle improvements.

Unexpected outcomes are common to the application and use of technologies. A classic example is provided by one of the possible scenarios explaining the epidemiology of BSE (Philips, et. al. 2000). Decades ago, in a country an ocean away, decisions were unknowingly made to allow a BSE infected cow into the food system and to feed her rendered meat and bone meal to other ruminants. Approximately thirty years later, a BSE infected dairy cow is discovered in the United States. The December 23, 2003, announcement of that discovery had a dramatic, yet short term negative impact on the cattle market. Its possible long term impact on consumer demand, country of origin labeling, individual animal identification, age at time of slaughter, and the testing of increased numbers of animals is yet to be determined. Cause and effect are indeed distant in time and space.

Technology designed for cattle production systems needs to be evaluated not only with a cost benefit analysis, but also an understanding of the marginal costs of its application, production functions, and an evaluation of possible implications, interactions, and unexpected outcomes. The evaluation needs to look at technologies not only in their present context but in light of the future.

Cost Benefit Analysis and Partial Budgets

Cost benefit analysis can be made with the help of a partial budget. A partial budget is an estimate of the changes in income and expenses that would result from carrying out a proposed change. An example can be found Table 1. This simple procedure quickly establishes an estimated cost of the application of a technology and compares it to the estimated change in income that results from the use or application of the technology. If the difference is a positive change in net income, it is usually recommended that the technology be adapted.

Table 1. Partial Budget (Kay and Edwards, 1999)

Partial Budget	
Technology:	
Additional Costs:	Additional Revenues:
Reduced Revenue:	Reduced Costs
A. Total additional costs and reduced revenue $	B. Total additional revenues and reduced costs $
Net Change in Profit (B-A)	

While this process seems fairly straightforward, what it doesn't measure may be as important as what it does. For example, risk, affect on cash flow, debt, repayment capacity, inter-relationships, variability, repeatability, and quality of life are not measured with partial budgets. While some technologies are simple and straightforward, others are not, and capturing some intrinsic feel or estimate for things like risk is critical. Beyond the things that a partial budget obviously does or does not measure, there are always unexpected outcomes to change. An example would be the European trade embargo on US beef because of the use of growth-promoting hormone implants. The loss of market share and its impact on total demand for beef due to the European trade embargo can be measured now, but 25 years ago was unforeseen. A simple partial budget for implanting beef cattle in 1979 would not have been sensitive to the future loss of market share due to trade embargos.

Several other limitations should be discussed. A partial budget does not compare alternatives. While one can create several partial budgets and compare the results, the assumptions one makes to do this may be excessive. One basic assumption for this type of multiple analyses is that all other things are equal. They rarely are. Other assumptions made in the comparison of technologies with partial budgets are that either the results are additive or completely independent. Few are either. Another thing that a partial budget does not do is measure the efficiency of how resources are allocated. For example, perhaps Technology 1 may increase net income to level A. But was it an efficient use of limited resources? Perhaps Technology 2 could increase net income to ¾ A, but at a fraction of the investment. Partial budgets do not measure sensitivity or efficiency. If the results of partial budgeting are put into a ratio, a cost/benefit ratio, then comparisons of alternatives may be more appropriate. Care should still be taken.

In summary, their ease of use and understanding has led to the widespread adoption of partial budgets as a determinate in cost benefit analysis. While useful, they have limited value and must be used with caution.

The Importance of Using the Correct Endpoint

A key step in the evaluation of a technology is to measure its impact at the correct endpoint. Many evaluations of technology in the cattle business have been and continue to be based on a per head basis. For example, a treatment, application, or protocol is reported to cost X dollars per head. Or, it netted Y dollars per head. While interesting, it is much more important to know what the cost or return is per unit of weight sold. This is especially true of technologies aimed at cattle reproduction. A technology may increase pregnancy percentage, but the question becomes, does the advantage carry over to weaning and actually increase the number of pounds of calf weaned? It may or may not. At the very least it is important to know the cost of the technology is on a weight basis. When it comes to the application of a technology in the cattle business, a change in weight or in efficiency is the bottom line.

An excellent example of a comprehensive analysis of the impact of technology on an entire production segment can be found in the recent work of Sandy Johnson of Kansas State University (Johnson, 2002). Johnson compared two estrus synchronization protocols at three labor rates, three semen costs, and three pregnancy rates. The results (Table 2) were reported on a cost per cwt of weaned weight basis. This type of reporting allows a decision maker to evaluate technologies on their impact on the bottom line.

Table 2. 500 lb equivalent weaned calf breeding costs per cwt for a herd size of 100 at various labor and semen costs. (Johnson, 2002)

		Semen Costs								
Systems	Preg %	$3/unit			$13/unit			$23/unit		
		Labor Cost ($/hour)								
		5.77	10.77	15.77	5.77	10.77	15.77	5.77	10.77	15.77
CO-Synch	40	7.82	8.31	8.81	10.48	10.97	11.47	13.13	13.63	14.13
CO-Synch	50	5.36	5.85	6.35	8.01	8.51	9.01	10.67	11.17	11.67
CO-Synch	60	4.84	5.34	5.83	7.50	8.00	8.49	10.16	10.65	11.15
Select Sync	40	7.04	7.90	8.76	8.56	9.42	10.28	10.08	10.94	11.80
Select Sync	50	4.71	5.57	6.43	6.61	7.47	8.33	8.51	9.37	10.23
Select Sync	60	4.33	5.19	6.05	6.61	7.47	8.33	8.89	9.75	10.61

The Concept of Marginality

The understanding of the concept of marginality is a critical part of informed decision making. The principle of Marginal Utility is defined as the amount of additional benefits provided by an additional unit of an economic goods or service (Merriam-Webster, 2001). A classic marginal product curve is shown on Figure 1. This concept is not new. Gray (1968) discussed it in detail as part of ranch management decision making. The basic concept is that the level of economic measures, cost or product for example, will be different for varying levels of an input. As a production function reaches its point of diminishing returns, additional units of input do not correspond with increased levels of output. Also, the unit cost of the last units produced soars. One way to think about it in terms of a cattle production system is that once some other constraint has become limiting, no matter how many additional units of an input are added, the cattle cannot gain weight or reproduce at a higher level. A simple example would be bull to cow ratio. A 1:1 bull to cow ratio will not result in more cows bred or more weaned pounds when compared to a reasonable ratio that has been determined by size of pasture, breed, terrain etc. But it will add dramatically to the unit cost of production. The decision rule is that when the marginal value of the product produced exceeds the marginal cost of production, product should be produced (Kay and Edwards, 1999).

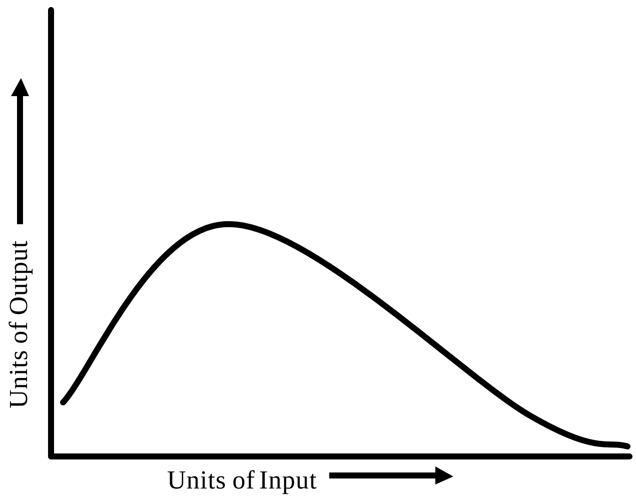

Figure 1. Marginal Product Curve (adopted from Case and Fair, 1996).

There are many excellent examples in beef cattle production. For example: level of nutrients like vitamins or minerals in feed, number of pastures in a rotational grazing system, stocking rate and animal performance on pastures. Other examples where the drop in production is not obvious but there is no increase in production as inputs increase would be dosages of drugs and protein level in feed supplements.

A second important example of the concept of marginality is its affect on costs. Figure 2 shows the impact on cost as levels of input are added beyond the point of diminishing return. The bull/cow ratio, dosage level of a therapeutic drug, and protein level of feed provide excellent examples. While they may be less obvious, all technologies have a Marginal Cost Curve. As one ponders the relatively low level of application of technology in some segments of the beef cattle industry (NAHMS, 1998), the question becomes, is it a matter of cattlemen ignoring potential benefits or an intuitive under stand this fundamental economic principle?

A third area where the concept of marginality applies is on price and revenue. A Marginal Price Curve looks different at the firm versus an industry level (Figures 3 and 4). Because a firm is very small compared to the market place, an increase in production at its level has no impact on price. However, at an industry level with constant demand, the impact on price of increased production can be dramatic. The cattle industry certainly observed these phenomena in the 1980's and 1990's. Beef production rose dramatically in the face of falling consumer demand, and the impact on the real price of beef was negative (Purcel 1998).

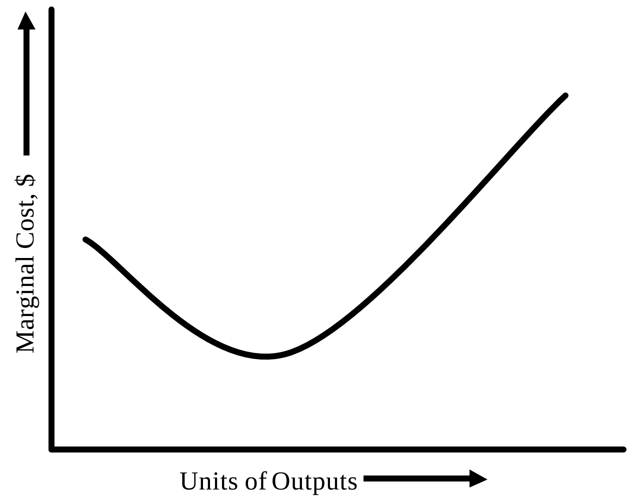

Figure 2. Marginal Cost Curve (adopted from Case and Fair, 1996).

At the ranch, farm, or feedlot level, changes in level of production has no impact on price due to sheer scale of the industry. So, while the adoption of a technology may be presented as having no affect on price, and that each unit of increased production due to the use of a technology will be priced at the same level (Figure 3), at an industry level this may be false. Industry-wide adoption may indeed lower price if demand is constant (Figure 4). This should be considered as an evaluator of technology thinks about the long term application of a technology. Being an early adopter of technology may have different benefits than being a late adopter. It is one thing to observe others to see if the claims about a certain product or protocol are true, it is another to let the benefits be eroded by changes in market dynamics.

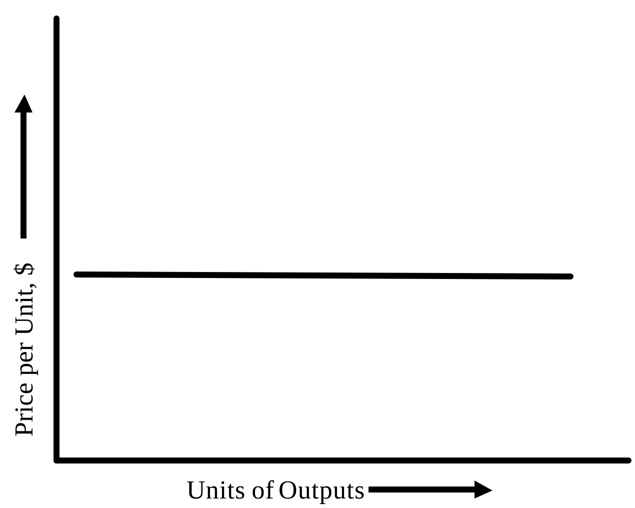

Figure 3. Marginal price curve for a firm (adopted from Case and Fair, 1996).

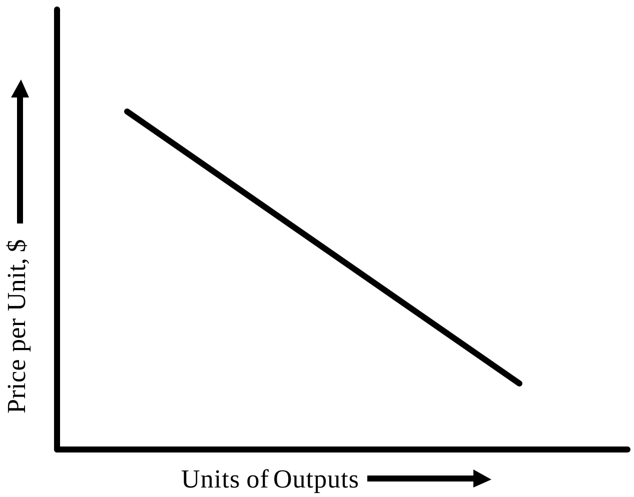

Figure 4. Marginal price curve for an industry at constant demand (adopted from Case and Fair, 1996).

Unexpected Outcomes

One of the characteristics of a complex system is that it exhibits unexpected outcomes to the application of policy or technology (Stermans, 2000). The possible epidemiology of Bovine Spongiform Encephalopathy (BSE) and the affect of growth-promoting hormone implants on beef demand are two of just many examples of unexpected outcomes in cattle production systems following a change in policy or technology. The expression of lethal traits as a result of inbreeding, bacterial resistance to antibiotics due to prolonged low level use, insect resistance to insecticides, negative associative effects in ruminant nutrition, and an increase in calving difficulty with the selection of breeding stock for weaning and post weaning growth are well known examples. Not all unexpected outcomes are negative. Planned crossbreeding systems have provided many positive unexpected results. Early evaluations of crossbreeding recognized the positive impact on growth traits and led to its promotion and adaptation. Later, other benefits of crossbreeding on reproduction, health, and longevity were recognized and measured. Another example of a positive, unexpected outcome of a technology is the feeding of all natural protein supplements to beef cows receiving high roughage diets. The all natural protein supplement not only meets dietary protein requirements but also enhances fiber digestion.

If unexpected outcomes to the application of technology are common, why then are they unexpected? Sterman (2000) suggests that it is because cause and effect are distant in time and space. For example, due to the long generation interval in beef cattle production systems, the result of changes in breeding programs often takes years to express themselves. Another hypothesis may be that under rigid, controlled experimental conditions, the evaluation of technologies is designed to minimize other effects. Even if unexpected outcomes occur, the data collection and analysis system in the evaluation process of an experiment may not be designed to recognize, monitor, or measure them. Also, the length of time that experimental observations occur is often too short to measure other effects that manifest themselves after data collection has ended.

How can possible outcomes of the application of technology be anticipated? A tool called Casual Loop Diagrams is used by many businesses and organizations to analyze the impact of changes in technologies, polices, or procedures (Senge et. al., 1994). This process of diagramming multiple cause and effect relationships helps investigators explore the mental models under which they operate. It might be described as organized pictorial brainstorming. Causal Loop Diagrams can also be used in the development of simulation models (Repenning, 1998). While not a crystal ball, the technique of using Causal Loop Diagrams to build and parameterize simulation models has many success stories dating back over 40 years (Sterman, 1991).

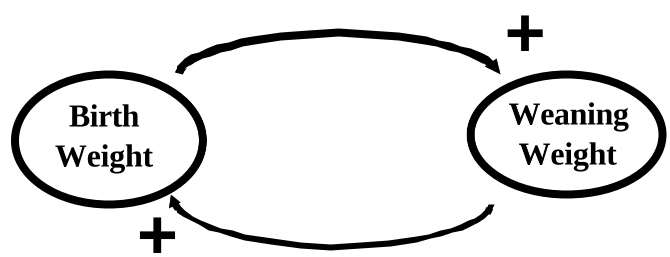

Figure 5. Causal Loop Diagram. Plus sign indicates that change occurs in the same direction.

The Causal Loop Diagram in Figure 5 depicts the genetic correlation between two traits, Birth Weight and Weaning Weight. As selection pressure is placed to increase Weaning Weight, Birth Weight also increases and vice versa. Causal Loop Diagrams can have many variables and depict complex inter-relationships. When information exists concerning the relationship between variables, as it does in this example, simulation models can be parameterized. If on the other hand, the development of a Causal Loop Diagram identifies a relationship that has not been defined, an area of future research needs has been identified.

Measuring the Future Value of a Technology

While many technologies may produce short term financial gains, changing market conditions may erode benefits over time. It is important to measure this phenomenon as accurately as possible. A partial budget measures the profitability of change in a single production cycle. What is the value of a technology years in the future? The process of making that determination is referred to as calculating the net present value of the benefits. The basic assumption behind the concept is that future earnings will be eroded by the inflationary nature of the economy. The general formula for calculating net present value of future values is (Workman1986).

$$V_n = V_o (1 + i)^n$$

In this formula, V_n is the future value of a present sum at the end of *n* years, V_o is the present sum, *I* is the interest rate charged during the period, and *n* is the number of periods over which Vo is compounded.

Due to the relatively long production cycle of the beef animal and its long generation turnover, the benefits of reporting results of the evaluations of technology in this manner are obvious. It also becomes the responsibility of the evaluator of information to think about benefits in context of their future value. Table 3 (Meek et al., 1999) provides an excellent example of the use of net present values in the evaluation of different aged beef cows. Culling strategies, purchased versus raised replacements, drought management plans, and investment strategies could all be impacted by the different net present values for the two market scenarios. While the rank of the residual values between the two market scenarios in Table 3 is the same, the absolute differences are important to consider. A twelve year old cow in the current market scenario has 70% more residual value than a 12 year old cow in the low point of the cattle cycle. This difference impacts many things on a cattle operation including cash flow, repayment capacity, and the ability or willingness to accept risk. The application of technology may also be different in the managerial response to the example in Table 3. For example, a drop in gross income may incline a manager to wait on the use of products or protocols until the operations cash flow improves.

Table 3. Net present values (NPV) for cattle of ages 1 through 12 yr for two market scenarios. (Meek et al.,1999)

Age of cow, yr	Residual NPV Current cattle market, $	Residual NPV Low point in cattle cycle, $	Remaining life (weighted average), yr
1	783.53	599.69	4
2	1,026.86	794.36	4
3	1,145.81	909.78	5
4	1,210.20	954.46	6
5	1,170.59	936.69	6
6	1,088.04	874.93	5
7	1,068.73	853.35	5
8	1,027.38	797.32	5
9	976.12	714.82	4
10	899.87	612.88	4
11	794.09	480.57	3
12	734.60	431.32	2

One of the difficulties of these types of analyzes is the volatile nature of the commodity beef cattle market. Another difficulty in looking forward in the beef cattle business has been the cyclical, but still unpredictable, nature of the business. Layering estimates of discount rates, the cattle cycle, consumer demand, the price of competing meats, and sensitivity estimates into a decision model is a daunting task. But as the industry moves towards value-based integrated marketing, reporting results of change in discounted future values will be increasingly important.

Summary and Conclusions

The evaluation of the impact of technologies on beef cattle production systems can be enhanced by placing them in their proper context. Suggestions for doing so include:

1. Cost/benefit analysis is a more effective evaluation tool than are simple partial budgets.
2. End weights or market weights should be the denominator of the analysis of economic efficiency rather than per head.
3. Costs and benefits of a technology will change with different levels of production.
4. Technologies may impact individual operations differently than they do the cattle industry as a whole.
5. Unexpected outcomes to the application of technology will be common due to the complicated nature of the business, its long production cycle, and its susceptibility to changes in uncontrollable environmental factors.
6. The future value of technologies needs to be appropriately discounted.

While challenging, it is critical to evaluate technology accurately and appropriately.

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