Optimal Production vs. Maximal Production

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Dairy production involves the use of resources (land, capital, labor, cows, etc.) in a process that produces products (milk, meat, and manure) valued by society. The production process has changed over time and will continue to evolve into the future. New technologies are always emerging as our knowledge of the dairy cow and her production attributes increases. These technologies are adopted if their marginal cost of implementation is offset by a greater marginal return for the producer and ultimately, society at large, in the form of cheaper products. For any technology, only marginal costs and returns are important in decision-making at the producer level; while fixed costs can be ignored at least for the decision-at-hand. Two broad fundamental strategies have been employed to define optimal production practices over the years invoking the principle of marginality. First, the industry has developed and embraced technologies that allow for the aggregation of more cows/herd. Secondly, the industry has dramatically improved the yield/animal through a host of improved management strategies. The modern dairy producer must manage the implementation of these strategies to be successful. Concepts of economic optimality will be discussed as they relate to the dairy industry. Samples of visual analytics used to explore opportunities for optimal production will be discussed.

THEORETICAL DETERMINATION OF OPTIMALITY

All production systems involve the use of variable inputs that are converted to products. The relation between a variable input and outputs produced defines a production surface. This relationship can be shown in terms of physical inputs to outputs, or in terms of the economic value of inputs and outputs (Figure 1). This relationship often follows a sigmoid shape, where at low levels of input there is linear or accelerated response in production for each additional level of input. At higher levels, the output response often dampens and can even result in a decrease in production (for example, toxicity in nutrient excess). Optimal production (in terms of maximizing profits) occurs when the marginal cost of an additional input is exactly equal to the marginal revenue received in response. Graphically, this occurs when the slope of the cost curve (marginal cost) is equal to the marginal revenue. At this point the response surface is maximally distant from the variable cost curve (the line tangent to the production response is equal in slope to the cost line). Deviations from this level of input, on either side, will result in lower profits. Furthermore, this point is independent of fixed cost (fixed costs are those costs that will not change over the immediate planning horizon) which are horizontal on the graph. In general, optimal production occurs prior to maximal production.

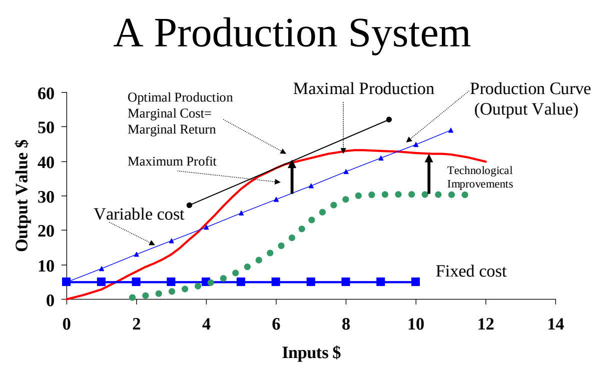

Figure 1. Production curve showing input to outputs.

This simple principal is behind many of the structural changes that have occurred in animal agriculture over time. Herds and flocks have increased in size to spread fixed costs over more animal units and ultimately over more products. Yield per animal unit has increased to *spread* animal maintenance costs (and replacement) over more units of milk production.

Addition of cows/herd will decrease the overhead cost of the operation over ultimately more units of product. The national herd has increased average herd size at an annual rate of nearly 5 % over the last 10 yr. Over the same time horizon, yield/cow has increased at 1.7 %/yr. The production curve (Figure 1) and cost curve change in magnitude as society changes the economic values of inputs relative to outputs, while the shape changes when technologies are changed. All technologies were at one point variable inputs to a

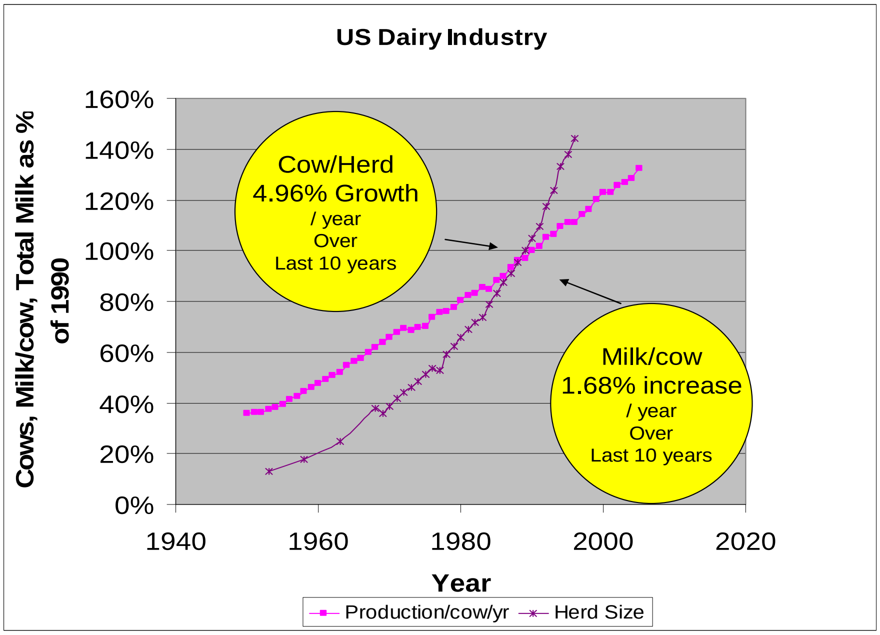

Figure 2. Historical trends in the dairy industry demonstrating the dilution of overhead management cost by aggregating more cows/herd and diluting animal maintenance cost by increasing the milk yield/cow/year.

given production system and those with favorable economic margins are embraced and become *fixed* over time. A successful technology or management practice can be defined as an input that was once variable and now is a fixed cost when it is almost completely adopted by the industry.

TOOLS TO FIND *OPTIMAL PRODUCTION* TECHNOLOGIES AND STRATEGIES

Partial budgeting is an economic methodology that uses the principle of marginality to evaluate if a given decision's marginal returns are greater than the marginal cost and thus contributory to optimal production. This is done by identifying changes in revenues associated with a decision as well as changes in cost. Fixed cost can be ignored as seen in figure 1, greatly simplifying the calculations. When the net of these changes is positive, a marginal opportunity for profitability exists. Partial budgets can be extended to include other attributes of revenues and costs associated with a given decision, such as the timing of the cash flows (discounting) as well as their variability characteristics (risk; Brealey and Meyers, 2000). Thus, for each technology or strategy, the fundamental marginal revenues and costs, as well as the attributes (timing, risk) must be accounted for. A bottleneck on a dairy can be defined as a strategy or technology that is currently not being pursued and yet it offers a positive partial budget.

To explore these potential *bottlenecks* of production, visual analytics (Galligan, 2007) have been created so that producers and consultants can see the impact of the implementation of technologies and management changes for their production system. A complete set of these analytics can be seen at:

URL: http://dgalligan.com/galliganx/visualanalytics/visualanalytics.html
Logon: guest
Password: guest

SAMPLE ANALYTICS

Cow NPV Model (Figure 3): The net present value (**NPV**) model of the dairy cow projects a series of future cash flows based on biological and economic parameters manipulated by the user. Biological parameters include lactation performance (amount of milk as well as the shape of the lactation curve), product use and response potential, and pregnancy rate, as well as economic parameters including milk price, feed, and breeding cost. The program discounts the revenues and costs and calculates a net present value and an equivalent annuity value of the net profit/cow/yr. These values are presented to the user in gauges so that as the parameters are manipulated with sliders, the sensitivity impact can be dynamically visualized.

- The NPV is calculated as well as the annuity value (payment/year) associated with the decisions described through manipulation of the management and economic sliders.
- A positive NPV indicates a technology or strategy which offers a return greater than the discount rate (weighted cost of capital) of the operation and thus is a lucrative investment.
- Negative NPV values are investments whose returns are below the rates of return already achieved by the operation at large. (This assumes that the investment under consideration has similar risk attributes as those reflected in the discount rate.)

Weighted Cost of Capital (Figure 4): A dairy consist of many assets (cows, land, buildings, etc.) and these assets are either owned (equity) or debt financed. At a minimum, each dollar invested in the dairy must bring a rate of return to offset debt (adjusted for the tax benefits associated with interest payments) and grow equity at a rate that is satisfying to the investor. The resulting rate is called the weighted cost of capital (**WCC**) and should be used as a benchmark to evaluate new decisions and technologies being considered for implementation on the dairy. Decisions of similar risk that offer a greater return than the WCC are worth an investment. If the WCC is used as the discount rate, NPV greater then zero offers a return greater then the WCC rate. The visual analytic in Figure 4 allows the user to dial in values (debt/cow, equity/cow, debt rate, equity growth rate, tax rate) relative to their operation.

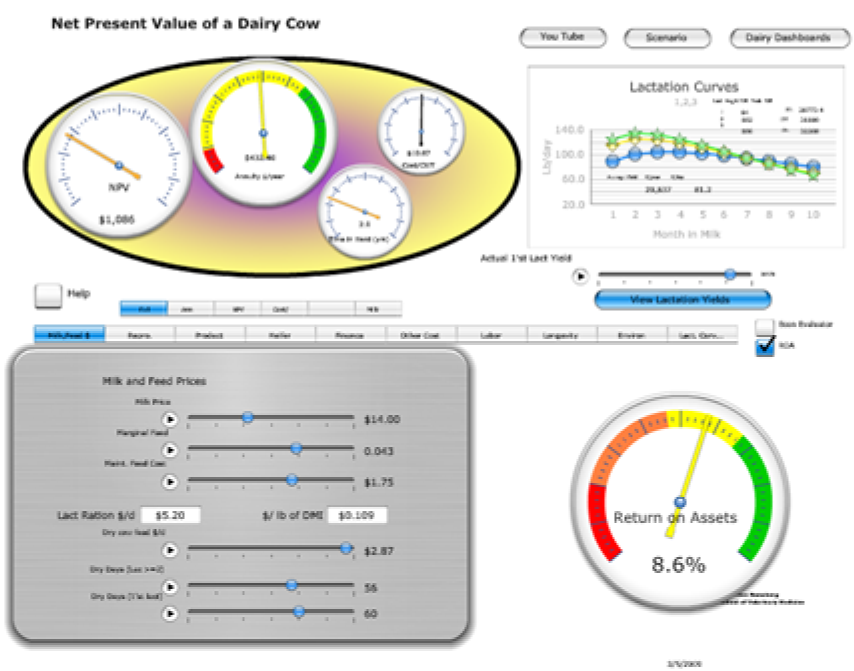

Figure 3. Net present value of a cow.

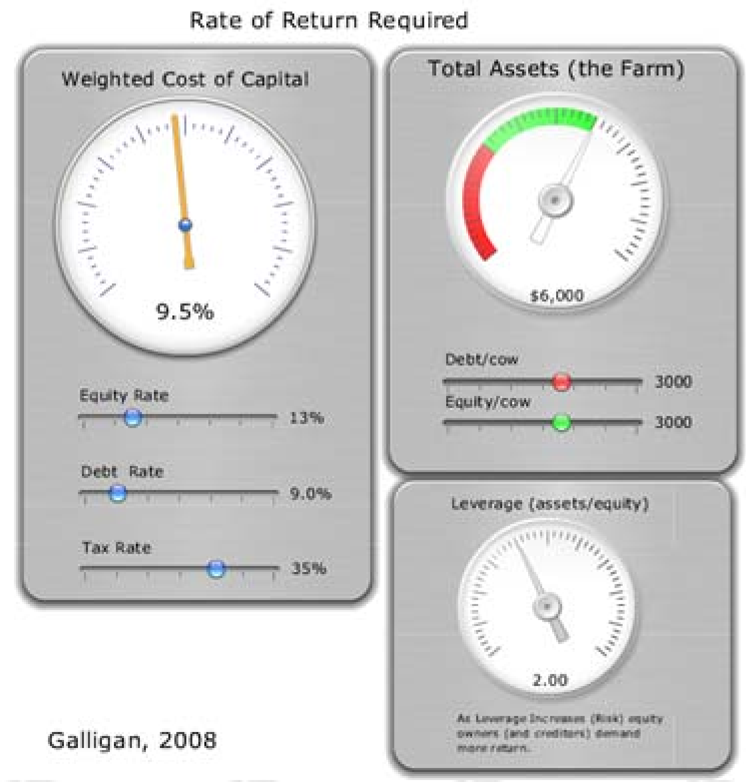

Figure 4. The weighted cost of capital for a dairy with a given debt and equity level per cow.

For example, a herd with total investment/cow of $6000, with $3,000 of that investment debt, must realize a rate of return of 9.3 % if it is to grow equity at 13 % and repay debt at 9 % (assuming a marginal tax of 35 %).

Dairy Finance (Figure 5). The dairy finance evaluator (Figure 5) is a visual analytic that allows the user to enter values in the profit loss statement (revenue and cost) as well as values in the balance sheet (assets, liabilities). Financial key performance indicators for herd profitability (return on assets, return on equity, net income), solvency (debt to asset ratio, debt to equity ratio, equity-to-asset ratio), and liquidity (current ratio, quick ratio, working capital) are calculated based on entered values. Sensitivity of these performance indicators can be observed by manipulating the sliders in both the balance sheet and the profit loss statement. The formulas used to calculate the key performance indicators can be seen by clicking on the icon under each gauge.

SUMMARY

Dairy producers are constantly challenged to find economical opportunities on their operations. To grow their business economically, they must pursue decision strategies that offer higher rates of return compared to the returns realized on the current assets. The principle of marginal analysis, applied in the form of partial budgeting is a useful approach to identify changes in marginal costs and revenues for a variety of opportunities commonly seen on the dairy. Visual analytical tools allow the concepts of partial budgeting to be presented dynamically for a given decision. It is a format that allows the user to manipulate parameter values and thus perform instant sensitivity analysis.

Figure 5. The dairy finance analytic where the user can enter in a balance sheet and profit loss statement for a dairy.

REFERENCES

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