Forecasting Future Sales and Profit for Value-Added Agriculture

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This research analyzes factors affecting product and profit lifecycles for new value-added products. The methodology presented shows how sales and profits evolve and how exogenous factors such as initial marketing efforts affect sales and profits. Results indicate that producers can increase the level of profits over time through initial marketing efforts. The theoretical model is applied to a quality cattle program to assess the analytical performance of the model.

Value-added agriculture stems from using a commodity to produce a product that is either a complement to or substitute for an existing end-use or industrial product. Sometimes the product is differentiated very little (e.g., ethanol) and other times the product displays significant differentiation (e.g., Blue Diamond Almonds). Most of the economic questions surround the significantly differentiated value-added products. The most important questions are, "How profitable will the new product be?" and, "How long will the profit stream last?" General wisdom is that the profit stream will shorten as competition arises. The objective of this study is to show, through comparative dynamics, the value to agricultural producers of initial marketing efforts of extending a product's lifecycle.

Product-lifecycle theory is widely used in the marketing-strategy literature to evaluate the expected sales and profit levels for new products or a product-line extension. The theory predicts that profits will increase as sales increase. They will then reach a maximum, after which profits will trend to zero because of competitive factors. However, certain choices and actions can change the length of the product lifecycle, most importantly the period for which profits are positive. These factors include initial marketing efforts (delay factor), the time at which profits obtain the maximum (inflection point), and the projected sales ceiling.

The results of the current research are directly applicable to value-added businesses seeking a competitive advantage during startup. Furthermore, this research can be used to emphasize the need for adequate initial working capital.

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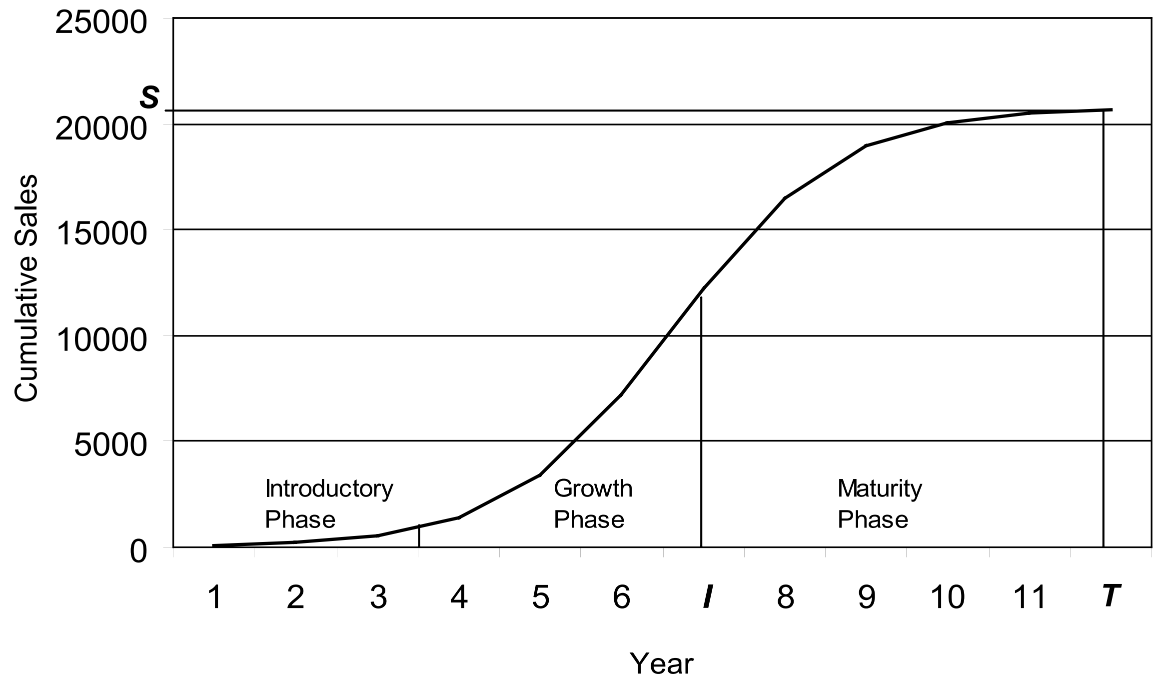
Theoretical Model

The product-lifecycle approach has been used to analyze and forecast sales and profit levels. Cox (1967) showed that the lifecycle of a new product is characterized by four stages: introduction, growth, maturity, and decline. The introduction stage is when the product is first marketed and sales are less than five percent of the market share. During this period, profits improve from negative to positive. In the growth phase, sales volume increases rapidly, and positive profits continue to increase. The growth phase ends with profits reaching the maximum level. The next phase is the maturity phase, in which both the rate of increase in sales volume and profits plateau and begin to decline. The last phase is the decline stage. During the decline phase, both total sales and profits decline rapidly. Figure 1 shows the stages of the product lifecycle (Cox 1967) and Figure 2 shows the corresponding profit lifecycle. In the literature, the profit lifecycle is obtained implicitly from the product lifecycle, but an analytical framework for the profit lifecycle is missing. As the decline stage is economically undesirable, the current study does not take into account this stage.

The formulation of the product lifecycle model is (Cox 1967)

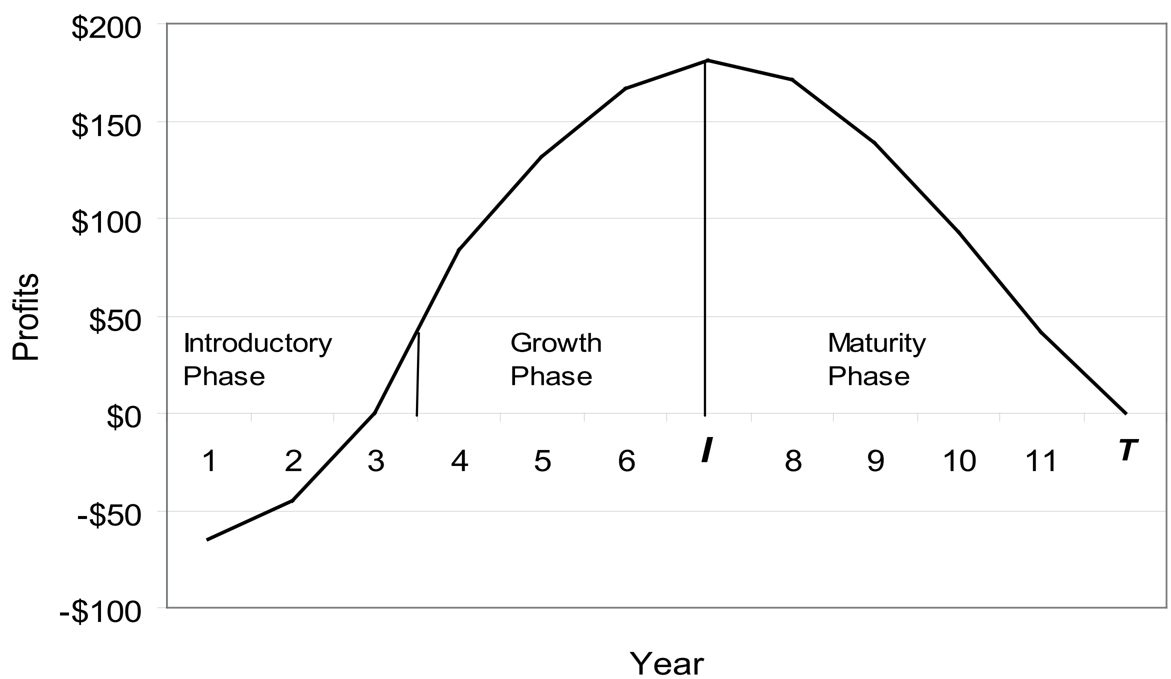
$$(1)\quad F_t = \frac{S}{1+e^{A(I-t)}} \quad \textit{for } t = 1,2\ldots T,$$

where t is the index for time, F_t is the cumulative sales level at time t, S is the saturation (maximum) level of sales, T is the time at which cumulative sales reach the saturation level of sales and I is the inflection point and the time at which profits reach the maximum—the beginning of the maturity phase. A is the delay factor which shows how long the



Note: Vertical axis values for presentation purposes only.

Figure 1. Product Lifecycle Example.



Note: Vertical axis values for presentation purposes only.

Figure 2. Profit Lifecycle Example.

sales of a product will stay in the introductory phase ($A \in [0,1]$). A value of A close to one indicates a long introductory phase, whereas a value close to zero indicates a short introductory phase. A short introductory phase is desirable in that it allows positive profits to be rapidly obtained. In general, marketing efforts in the introductory phase cause A to approach zero (Morrison 1995).

Morrison (1995) graphically presented the effect of a change in the levels of S, I, and A on the product lifecycle. However, the analytical framework to analyze the effect of these changes simultaneously on the product lifecycle or F_t was missing. The present study provides the analytical framework to show how changes in S, I, and A simultaneously affect the shape of the product-lifecycle curve.

The change in F due to a change in A can be represented as

$$(2)\quad \frac{dF_t(S(A),I(A),t,A)}{dA} = \frac{\partial F_t(.)}{\partial S}\frac{dS}{dA} + \frac{\partial F_t(.)}{\partial I}\frac{dI}{dA} + \frac{\partial F_t(.)}{\partial A} \quad \textit{for } t = 1,2\ldots T.$$

The results show that for $t < I$, $F_t(.)$ increases by decreasing A. However, for $t > I$, $F_t(.)$ decreases by decreasing A.[1]

Even though sales are important for producers, and the product-lifecycle model analyzes sales, the profits obtained from sales determine whether companies continue production. The product-lifecycle model does not provide an explicit formulation for the profit function. However, we show how initial marketing efforts affect profits.

Profit Lifecycle

To observe the change in the level of profits at each period, the profit function is specified as[2]

$$(3)\quad \pi_t\left(\frac{\partial F_t(S(A),I(A),t,A)}{\partial t}\right) = P_t\frac{\partial F_t(.)}{\partial t} - c(A) - b\frac{\partial F_t(.)}{\partial t} \quad \textit{for } t = 1,2\ldots T,$$

where $\frac{\partial F_t(.)}{\partial t}$ is the derivative of the cumulative-lifecycle function with respect to t, which gives the instantaneous sales amount at time t, while P_t is the price of the product at time t. A linear cost function is assumed with respect to an instantaneous sales level in which b is the slope and $c(A)$ the intercept. The term $c(A)$ includes the initial marketing cost and fixed production costs, which implies $\frac{dc(A)}{dA} < 0$, as marketing efforts reflect a decrease in A. We assume $c(A)$ does not trend over time and is only affected by A, where A can only be altered during the introductory phase. The effect of a change in A on the level of profits attained in each period is[3]

$$(4)\quad \frac{\partial \pi_t(.)}{\partial A} = \begin{cases} +/- & \text{for } t \in \{\text{Introductory Phase}\} \\ - & \text{for } t \in \{\text{Growth Phase}\} \\ - & \text{for } t \in \{\text{Maturity Phase}\} \end{cases}.$$

The negative sign in Equation 4 indicates initial marketing efforts cause profits to increase for the corresponding years and the positive sign indicates a decrease in profit due to initial marketing efforts. As the change in $c(A)$ through initial marketing efforts occurs only in the introductory phase, profits are expected to be lower in the introductory phase (initial years) and higher in the years following the introductory phase due to increased sales. Depending on the magnitude of the marketing costs, positive profits may also be realized in the introductory phase.

Application of Product- and Profit-Lifecycle Theories

The Show-Me-Select (SMS) Heifer Program of Missouri was initiated in 1997 to develop a high-

[1] Appendix information that shows the derivation of the result is available from authors upon request.

[2] Figure 2 shows the profit curve for S = 21000, A = 1, I = 7, and T = 12.

[3] Appendix information that shows the derivation of the result is available from authors upon request.

quality, branded, bred heifer supply—effectively creating an increased value via branding for the heifers. Profitability was a crucial criterion for farmers to remain participants in this program. We use this example because of the completeness of available data to provide credence to the theoretical model.

The data needed to formulate cumulative sales and profits for the SMS Heifer Program was obtained via the documentation of SMS Heifer Program special sales, available for the 1998 through 2004 period (Patterson and Randle 2006). The data used in the simulation analysis were obtained by aggregating the information supplied by individual producers. Therefore the results more closely reflect changes in Missouri beef industry levels. Bayus (1998) demonstrates that the length of a product lifecycle can differ for individual producers and suggests that the conclusions about the product lifecycle should be made based on industry-level data instead.

The use of the product-lifecycle method requires sales data. However, for new products a forecast of sales is the only available information. Morrison (1995) provides approximation methods for parameters in the product lifecycle of new products. More specifically, an estimated version of Equation 1 can be used to arrive at

$$(5)\quad \hat{F}_t(.) = \frac{\hat{S}}{1+e^{\hat{A}(\hat{I}-t)}} \qquad \text{for } t = 1,2...T,$$

where $\hat{S}$ is the approximated value of the saturation level of the sales volume, $\hat{A}$ is the estimated significance of the delay factor, and $\hat{I}$ is the projected value of the inflection point. According to Morrison (1995), the value of $\hat{S}$ is found to be the maximum cumulative amount of sales the product is expected to achieve.[4]

The total number of registered heifer buyers attending sales for 2003 was 595, the average herd size for a registered buyer was 90 animals, 61 percent of the registered buyers bought SMS Heifers, and 73 percent of those who bought SMS Heifers indicated they want to continue buying SMS Heifers (Parcell et al. 2005). The number of actual buyers is calculated by multiplying the total number of registered buyers (595) by the percentage of buyers who actually bought heifers (61 percent). To approximate the number of future buyers, the number of actual buyers (363) is multiplied by the number of buyers who want to continue buying SMS Heifers (73 percent). Finally, to find the expected future total sales of SMS Heifers, the average herd size (90 head) of these actual buyers is multiplied by the estimated number of future buyers, equating to $\hat{S}$ = (595 * 0.61 * 0.73) * 90, or 23,845 heifers.

The value of $\hat{A}$ and $\hat{I}$ are calculated by using the non-linear optimization procedure from Kros (2005). Using the calculated value of $\hat{S}$, the values for $\hat{A}$ and $\hat{I}$ are selected to minimize the sum of squared errors between the actual cumulative sales data and the expected value of cumulative sales for heifers in the program between 1997 and 2004. Specifically,

$$(6)\quad \min_{\hat{A},\hat{I}} \sum_{t=1}^{8} (F_t - \frac{23,845}{1+e^{\hat{A}(\hat{I}-t)}})^2$$
$$s.t.$$
$$0 \le \hat{A} \le 1,$$
$$0 \le \hat{I},$$

where F_t is the actual cumulative sales data for year t. Two constraints are assumed: $\hat{A}$ is between zero and one, and $\hat{I}$ is positive. $\hat{A}$ is found to be 0.37. The small magnitude of $\hat{A}$ is likely due to significant initial marketing efforts for the SMS Heifer Program.[5] The value of $\hat{I}$ is 7.5, showing that profits for the program continued to rise for 7.5 years after the program began.

[4] An example is beneficial. Following Morrison (1995), for a producer who wants to sell a new type of tomato in a small town, $\hat{S}$ is calculated. It is known by this producer, from market research, that there are 1,000 people in the town who buy tomatoes, two every year. Also, through consumer surveys it is learned that 25 percent of the potential consumers will purchase a new tomato. From the market information, the saturation level of sales is approximated $\hat{S}$ = 1000 * 2 * 0.25 = 500 tomatoes.

[5] Producer-owner representatives at sale locations advertise widely, with the University of Missouri Extension system serving as catalyst for marketing efforts. The consignment cost for each heifer marketed through registered sales ranges from \$15 to \$20 per animal. Most of this consignment fee goes toward marketing. In addition, the University of Missouri Extension service offered free news releases for this program because it was initiated through University of Missouri Extension monies.

The shape of the cumulative lifecycle (CLC) curve for the SMS Heifer Program is created with two different values of $\hat{A}$, 0.37 and 1 (Figure 3). Recall, an $\hat{A}$ equal to 1 indicated no marketing effort. As can be seen from Figure 3, when $\hat{A} = 1$ the shape of the CLC curve is similar to the shape generally displayed in textbooks. Total sales are initially low, grow rapidly, then reach maturity. When $\hat{A} = 0.37$, a higher level of sales can be reached at an earlier time in the introductory phase. As an example, the level of sales for year two is compared for each value of $\hat{A}$. In Year Two, total sales are projected to be 2,646 heifers when $\hat{A} = 0.37$ and 200 heifers when $\hat{A} = 1$. The actual data indicate that Year Two sales were 1,844 heifers. Overall, the CLC curve is better approximated by $\hat{A} = 0.37$ than by $\hat{A} = 1$.

As can be seen in Figure 3, a decrease in A causes both S and I to increase. The increase in S causes sales to increase for all periods, which is consistent with the findings of Morrison (1995). However, Morrison (1995) did not incorporate the change in S as a response to a change in A. For the SMS Heifer Program, the decrease in A causes the sales level to increase for Years One through Six and 13 through 19. For Years Seven through 12, sale quantities are projected to decline due to large initial marketing efforts.[6]

[6] If S can increase sufficiently, then the level of sales may not decrease for any period. This value of S is calculated to be 30,666 for SMS Heifer Program. However, this value of S could not be obtained even for $A = 0$. Hence factors other than A also need to be used to increase S. This point requires further research.

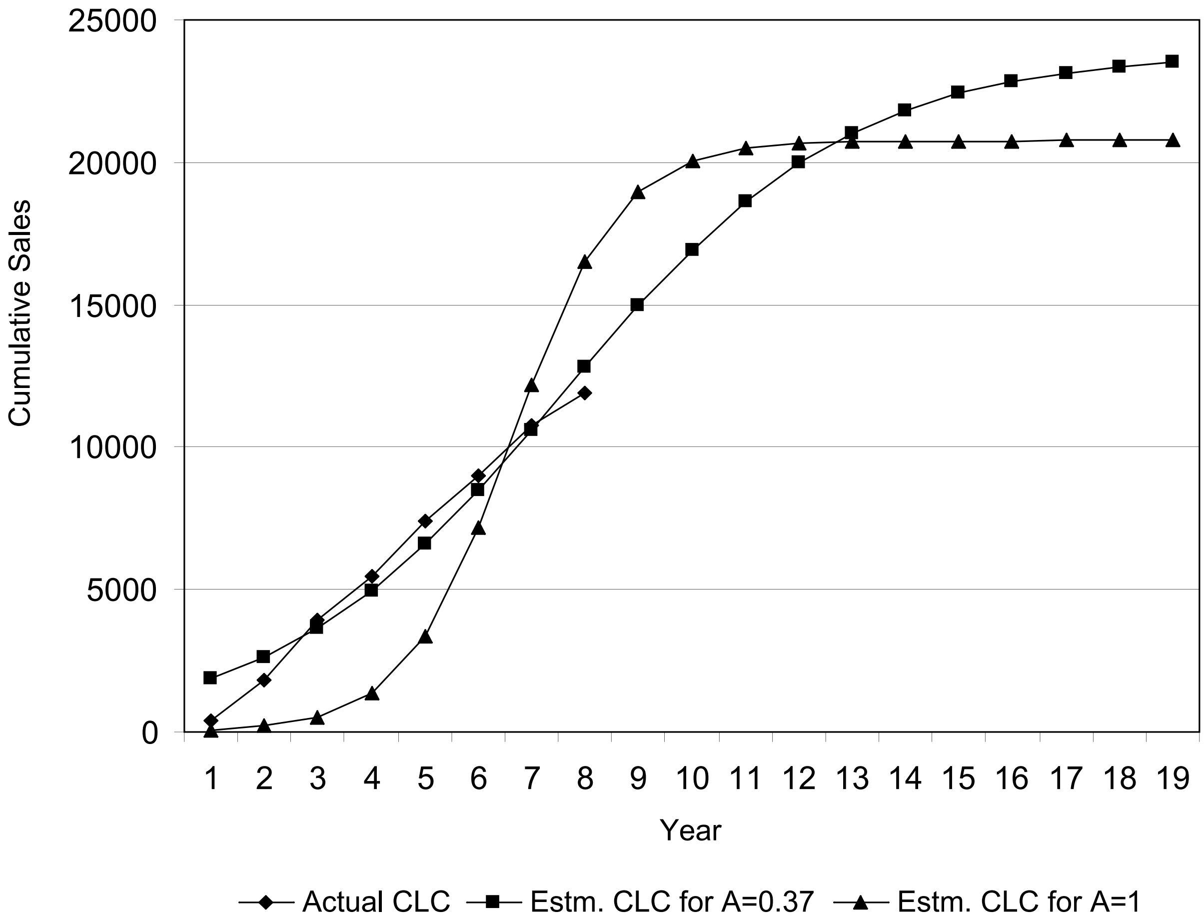


Figure 3. Comparison of Cumulative Lifecycle (CLC) of A = 0.37 versus CLC of A = 1.

It is possible to compare the net gain in sales from a decrease in A, i.e, increased marketing efforts, as A goes from 1 to 0.37. For an increase in marketing efforts, the heifer sales increase 15,489 head During Years One through Six, decrease 14,929 head During Years Seven through 12, and increase 12,887 head during Years 13 through 19. Therefore the increase in cumulative sales due to enhanced marketing efforts for the 19-year period simulated is 13,447 head.

A decrease in A causes I to increase. By decreasing A from 1 to 0.37 for the SMS Heifer Program, the inflection point I increased from $t = 6.5$ to $t = 7.5$. Thus early marketing efforts can substantially increase the time during which profits will continue to rise before peaking. Overall, the fact that actual sales data for SMS Heifer Program is better approximated by the CLC for $A = 0.37$ instead of the traditionally thought CLC for $A = 1$ shows that there will be a higher number of sales than expected and a longer period during which positive profits will be achieved.

Profit Curve

The profit function for the SMS Heifer Program is simulated following the cumulative lifecycle as

$$(7)\quad \min_{\hat{b},\hat{c}} \sum_{t=1}^{7} \left(\pi_t - \left[p_t \frac{\partial \hat{F}_t(.)}{\partial t} + \hat{c}(A) + \hat{b}\frac{\partial \hat{F}_t(.)}{\partial t} \right] \right)^2 .$$

The values of instantaneous rate of sales for each period, $\frac{\partial \hat{F}_t(.)}{\partial t}$, used in the estimation procedure are predicted from a previously estimated cumulative lifecycle for the SMS Heifer Program using the value $\hat{A} = 0.37$. To estimate the profit level for each year, the price level used, p_t, is the average price per heifer for SMS Heifer Program sales over the seven year period, \$981/head. The estimated profit curves for $A = 0.37$ and $A = 1$ are shown in Figure 4, actual profits are available for seven years.

Comparing the profit curves for $A = 0.37$ and $A = 1$ shows the effect of marketing efforts on profits. Initially, profits are lower for $A = 0.37$ than for $A = 1$. This is due to increased marketing expenditures. The profit levels for $A = 0.37$ become significantly higher after Year Six. Profits diminish faster for $A = 1$. This shows that producers receive more periods of positive profits when initial marketing efforts are undertaken. The approximate area under the profit curve for $A = 1$, over the seven-year period, is calculated to be \$617/head, while the area under the profit curve for $A = 0.37$ is \$955/head. When yearly profits for both levels of A are discounted by a discount rate of eight percent, the net cumulative gain through enhanced marketing efforts turns out to be \$156/head. The estimated cumulative gain is greater than the added cost incurred through a marketing campaign. While startup costs can be huge, in theory there is a greater chance of achieving profitability sooner by investing in initial marketing. This result reinforces the need to invest in marketing early in product development.

Brand Value

The general wisdom in agriculture is that the brand value created by product differentiation will last for a very short time, as replication of an agricultural product is often easy in comparison to other industries. However, we show that through marketing efforts, short-term profitability can be increased, and the period of profitability can be expanded. For the current study, the brand value is defined as the difference between the per-head profit levels for the SMS Heifer Program and non-program commercial bred heifers:

$$(8)\quad B_t = \pi_t^{SMS} - \pi_t^{non\text{-}SMS} \text{ for } t = 1,2, \ldots T.$$

π_t^{SMS} and $\pi_t^{non\text{-}SMS}$ are the profit levels for the program and non-program heifer for each period, respectively. The change in the brand value due to initial marketing effort can be represented as

$$(9)\quad \frac{\partial B_t}{\partial A^{SMS}} = \frac{\partial \pi_t^{SMS}}{\partial A^{SMS}} - \frac{\partial \pi_t^{non-SMS}}{\partial A^{SMS}}$$

$$= \frac{\partial \pi_t^{SMS}}{\partial A^{SMS}} - 0 = \frac{\partial \pi_t^{SMS}}{\partial A^{SMS}} \text{ for } t=1,2,\ldots T,$$

where $\frac{\partial \pi_t^{non-SMS}}{\partial A^{SMS}}$ is equal to zero because the initial marketing efforts for the program do not affect the profit levels of non-program heifers. Therefore the

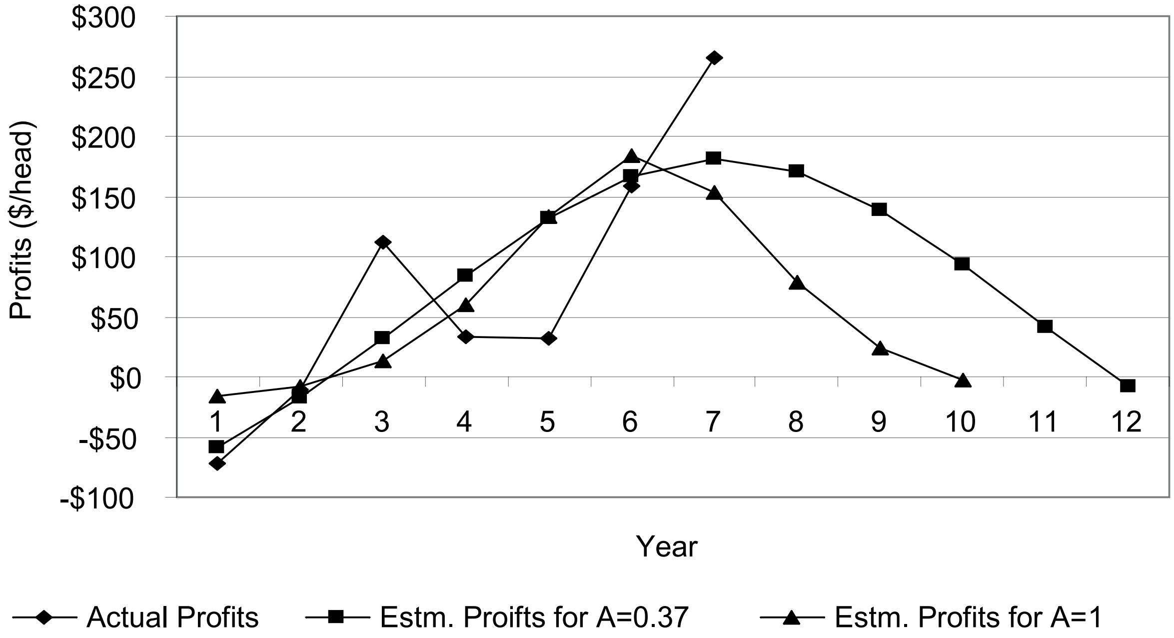


Figure 4. Profit Lifecycle for SMS Heifer Program.

total change in brand value due to the initial SMS Program marketing efforts is represented as the sum of changes in program profits for each period:

$$(10) \qquad \sum_{t=1}^{T} \frac{\partial B_t}{\partial A^{SMS}} = \sum_{t=1}^{T} \frac{\partial \pi_t^{SMS}}{\partial A^{SMS}} .$$

From Equation 10, the total increase in brand value will be equal to the total increase in profits between SMS Program heifers and conventional heifers. This is calculated to be $156/head. Hence by investing in marketing efforts the program increased SMS Heifer Program heifer value by $156/head.

The estimated brand value is shown in Figure 5. The positive brand value is expected to last for 8.5 years when initial marketing efforts are undertaken for the SMS Heifer Program.[7] The length of run for the brand value is extended by two years due to initial SMS Heifer Program marketing efforts. Thus initial SMS Heifer Program marketing efforts caused the brand value to increase in terms of an immediate price premium and due to long-term market penetration.

[7] In Figure 4, T is equal to 12 years for $A = 0.37$ and ten years for $A = 1$, which shows that positive profits are realized for two more years due to initial marketing efforts.

Conclusions

This research evaluates the theoretical and empirical impact of marketing efforts on the value-added agriculture product lifecycle. While the lifecycle methodology and comparative dynamics reported in the current research can be extended to non-agricultural products, the goal of the current research is to show how the application of such methodology can explain the lifecycle of value-added commodity goods.

The results indicate, through comparative dynamics, that the product lifecycle theorem is meaningful only after incorporating the impact of a change in initial marketing efforts. Thus the ability of a business entity to sustain profits from investments in a value-added business requires significant up-front investment in marketing. Through initial marketing efforts it is possible for the value-added business entity to decrease the amount of time until positive profit is realized and extend the number of

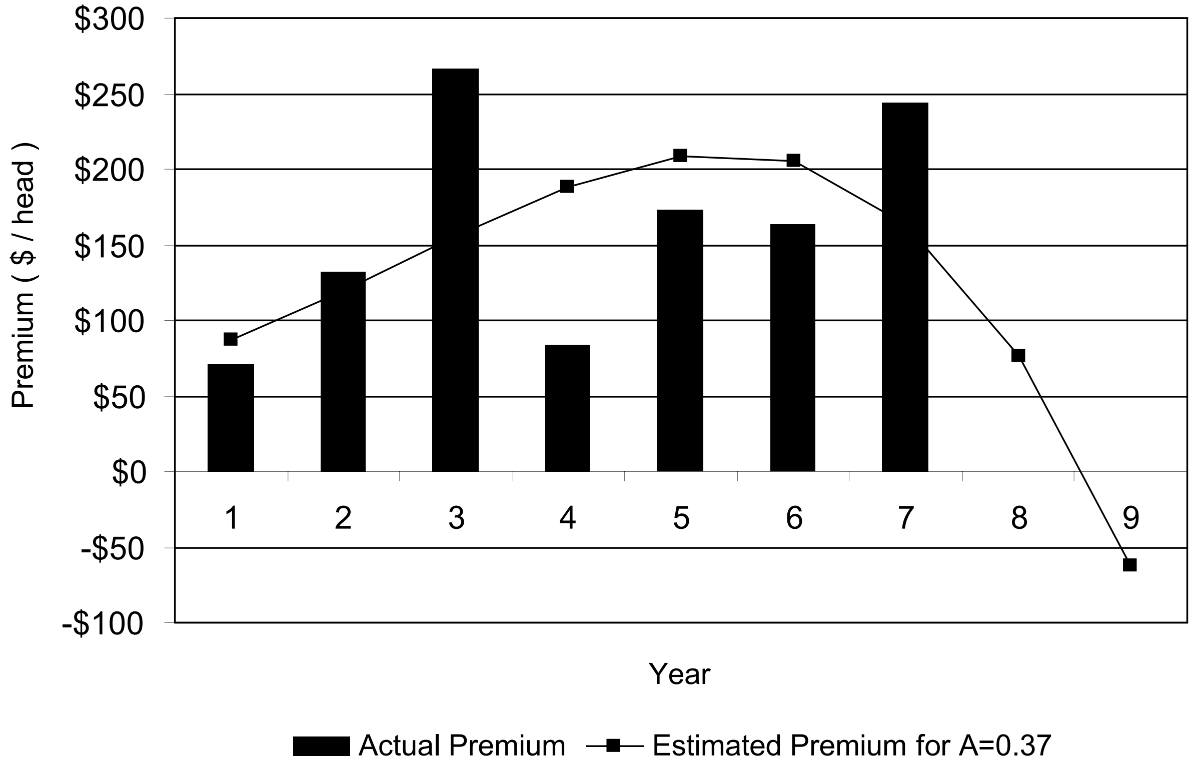


Figure 5. Brand Value for SMS Heifer Program.

periods producing positive profits. Furthermore, the findings of the current study indicate that allocation of monies for marketing efforts is a critical component for success, as shown with the effect of a decrease in *A* on sales and profit. When the product is successful, the increase in short-term profits outweighs the added marketing cost.

Finally, the product-lifecycle projection and profit-function analysis is applied to a producer value-added quality bred heifer program. Through simulation, the estimated level of price premiums for the bred heifer program was determined to be similar to actual premiums. Thus whether for a product or a differentiated commodity, the product-lifecycle theory applied here indicates marketing efforts are critical to the long-run success of the product and its ability to garner price premiums and generate a positive profit.

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