System Dynamic Approach to Assessing New Product Introduction: The Case of Functional Foods in the United States

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Abstract

Health care costs particularly those associated with chronic health conditions such as cancer have been significantly increasing for both individuals and governments in the past decades, prompting the demand for preventative medical initiatives, such as functional food, and spawning a new industry in the food sector – functional food industry. This article conducts a feasibility study for a firm entering the functional food industry with a specific product, Avert®, CLA-enhanced cheese. It also assesses alternative market conditions under which the firm will be successful. A system dynamics framework is used for the analyses. The results show that a firm can be profitable in the functional food industry provided that it satisfies certain pricing and target market conditions. The results indicate that the extent to which the market differentiates Avert® from commodity cheese, and hence the premium it pays, is a critical success factor for the firm introducing the product.

With improved scientific knowledge and technology, people are living longer with more diseases and disabilities than ever before and consequently, taxing the health care system. Functional foods are being considered as a 'magic food' to alleviate some of the health care costs associated with aging. Innovative food products are being developed to minimize the incidence and extent of illnesses and diseases in particular chronic health problems, thereby enhancing the quality of life especially as people age. Recently, the discoveries of new food components (e.g., phytochemicals) that do not contribute to basic nutrition but may prevent disease have presented a new dimension to the functionality of food. These foods are referred to as functional foods– foods that provide additional physiological benefits beyond meeting basic nutritional needs (Hasler, 2002).

US health care costs have been increasing at a dramatic rate over the past decade. A large majority of US health care costs is spent on treating illnesses associated with aging societies such as cancer. Cancer is the second leading cause of death in the US and is responsible for 25 percent of all deaths in the US. From the Cancer Statistics 2006 report, an estimated 564, 830 Americans will die from cancer in 2006 (ACS, 2006). When the deaths are aggregated by age, cancer has replaced CVD as the leading cause of death among Americans under 85 years of age (Jemal et al., 2005). The most prevalent cancers affecting aging societies are skin, lung, and hormone-dependent (e.g., breast and prostate) (CDC, 2004c).

While age and genetics play a role, approximately 50 to 75 percent of all cancers are lifestyle related and thus, preventable (National Cancer Institute, 2004). An individual can reduce their risk for cancer by achieving optimal health through avoiding tobacco use, being physically active, reducing sun exposure, and consuming a proper diet (ACS, 2004; WHO, 2005). According to the Cancer Research UK (2004), one-third of all cancers are linked to diet.

The total cost of cancer, including direct and indirect costs, in the US estimated by the National Institutes of Health in 2002 was $171.6 billion. An additional $3 to $4 billion from cancer screening test (e.g., mammograms) is added to the total cost. More than one half of the direct medical costs associated with cancer are attributed to breast ($6 billion), lung ($5 billion), and prostate ($5 billion) cancer treatments (ASCEND, 2003).

Improved quality of life and chronic health problems have become a major focus in functional foods research. There is an overwhelming amount of scientific evidence to support the protective effects of plant and animal sources against chronic health problems in particular certain types of cancer. Recent research has discovered many beneficial components in dairy products in particular conjugated linoleic acid (CLA). CLA is a naturally occurring fatty acid in rumen animals and its quantity in food products can be enhanced by feeding animals a specialized diet. Numerous scientific studies indicate that CLA has antiatherogenic, antidiabetic, antiobesity, and positive immune effects. However, the majority of the research supports CLA's anticarcinogenic properties.

Functional foods have the potential to provide significant health benefits that would result in reducing health care costs. By developing functional food products, the consumer could gain from both the resulting health benefits and the lower costs associated with health care and customized food products. However, these products will only be developed if innovative food firms manufacturing these products can maximize their profit. In other words, these firms must be able to generate revenue higher than the high cost associated with the development and regulation of functional food products. Therefore, this research seeks to answer the following primary question: Can a firm be profitable in the functional food industry? The secondary question asks the following: Under which conditions will a firm by profitable?

The article will review the scientific, business, and economic literature pertaining to the health benefits of CLA-enhanced food products with respect to cancer, evaluating the efficacy of CLA-enhanced food products in controlling chronic health problems. Specific product and market conditions needed for the firm to be successful will be identified. A system dynamic model will be developed to investigate the economic feasibility of introducing a CLA-enhanced food product provided that the conditions hold. A discussion of the results of the profits earned from the different scenarios will be presented. Finally, a conclusion along with recommendations for future research is presented.

CLA and Health Benefits

CLA is present in milk fat and adipose tissue[1] of ruminants. It refers to a group of polyunsaturated fatty acids derived from linoleic acid, which is isomerized by a rumen microorganism, *Butyrivibrio fibrisolvens*, to produce the transient intermediate CLA. Further reduction of CLA forms *trans*-11 octadecenoic acid (*trans*11-18:1 or vaccenic acid) and stearic acid. Interestingly, polyunsaturated fatty acids (e.g., linolenic acid obtained from pasture feeding, fish oil and linolenic oil feeding) through a number of biochemical reactions can be re-synthesized into *cis*-9, *trans*-11-CLA by delta-9-desaturase in the mammary gland and adipocytes. In fact, endogenous synthesis of CLA by delta-9-desaturase represents the major source of CLA in milk fat of lactating cows (Griinari et al, 2000).

The *cis*-9, *trans*-11-CLA isomer is the most naturally abundant form of CLA and contributes 85 to 90 percent of milk fat total CLA (Tricon et al., 2004). The other bioactive

CLA isomer is *trans*-10, *cis*-12-CLA (Belury, 2002). C*is*-9, *trans*-11 isomer has been proven to have antitumor and antiatherogenic effects whereas *trans*-10, *cis*12-CLA is thought to have antiobese and antidiabetic effects.

CLA has been found to be an anticancer agent at multiple stages of cancer development (i.e., initiation, promotion, progression, and metastasis) in multiple organ systems in the body (e.g., breast, prostate, skin, and colon). Mechanisms by which CLA's exerts its anticarcinogenic effects are by modulating free radical-induced oxidation, carcinogen metabolism and carcinogen-DNA adduct formation in the skin and other tissues. Consumption of synthetic CLA (consisting of relatively equal amounts of *cis*-9, *trans*-11-CLA and *trans*-10, *cis*-12-CLA) during or after the initiation stage of cancer development has been found to delay or reduce the onset of chemically induced skin tumor promotion or mammary and colon tumorigenesis (Belury, 2002).

The effects of CLA on post-initiation cancer development include its ability to reduce growth rates of mammary and prostate cancer cells implanted in vivo in mice. In one study, Hubbard et al. (2000) investigated the effect of CLA on the latency, metastasis and pulmonary tumor burden[2] in mice fed a 20 percent fat diet including CLA content ranging for zero to one percent. The mice fed the CLA diets experienced an increase in the latency of tumors compared to the group of mice not fed CLA. Results also suggest an inverse relationship between the amount of CLA in the diet and the volume of pulmonary tumor burden decreased. These findings suggest that CLA may have a positive effect on tumor incidence in the later stages of breast cancer (i.e., metastasis).

Another anticarcinogenic mechanism used by CLA is its ability to modulate cell proliferation[3] and apoptosis (programmed cell death). Palombo et al. (2002) studied the antiproliferative effects of commercially prepared CLA and its isomers (*cis*-9, *trans*-11-CLA and *trans*-10,*cis*12-CLA) using human colorectal and prostate carcinoma cells. Results of the study revealed that both CLA isomers had moderate effects against prostate cancer. In addition, *trans*-10, *cis*12-CLA isomer possessed the greatest potency against colorectal cancer and induced apoptosis in the colorectal and prostate cancer cells. These findings suggest that commercial prepared CLA may be an effective chemopreventive agent.

Other studies have determined that CLA induces apoptosis in mammary gland, liver, colon and adipose tissues by reducing levels of proteins (i.e., Bcl-2) that suppress apoptosis (Park et al., 2004; Belury, 2002). Studies have also suggested that CLA's effects on apoptosis may be attributed to CLA's effect on arachidonic acid metabolism. CLA has the ability to reduce the formation of eicosanoids, a class of lipids metabolites derived from arachidonic acid as well as decrease the metabolism of phospholipids fatty acids. This is a particularly important finding since eicosanoids modulate tumorigenesis in the mammary gland, skin, prostate and colon (Belury, 2002).

Although scientific evidence strongly supports CLA's ability to inhibit cancer development, a few studies contradict these results. CLA is thought to inhibit the growth of transplantation of cell lines from mammary and prostate. However, Hansen Petrik et al. (2000) discovered that CLA did not exert antitumorgenic effects. In the study, the antitumorgenic effects of CLA on $Apc^{Min/+}$ mouse (a useful model to study early intestinal tumorigenesis) and the changes in prostaglandin biosynthesis were examined. Results from the study revealed that the amount of CLA was not effective at the set dosage to inhibit tumorgenesis nor did it significantly affect prostaglandin levels. It is important to note that no research has discovered that CLA promotes tumorgenesis (Belury, 2002).

CLA Enhancement in Dairy Products

The CLA content in dairy products can be greatly increased by appropriate genetic selection, and a specialty diet but post-harvesting factors in the processing of dairy products (e.g., pasteurizating and aging) has little to no effect (Bauman et al., 2005). Individual variation in cattle within a herd can account for a two to three fold variation in CLA content in milk fat (Kelly et al., 1998a, 1998b; Lock and Garnsworthy, 2002, 2003). Kelsey et al. (2003) and Bauman et al. (2005) suggest that the majority of the differences in CLA content in milk fat among cows can be attributed to individual variation in delta-9-desaturase gene expression and the rumen outflow of VA and CLA. This difference may be attributed to genetic variation among the cows.

By placing the cow on a specific diet, farmers can alter the CLA content present in milk fat. Ruminants that graze on pastures have five times higher CLA content in their milk than ruminants fed a diet consisting of 50 percent forage (e.g., alfalfa and corn silage) and 50 percent grain (Harris, 2001; Robinson, 2002). Interestingly, dry feed diets comprised of two to four percent soybean and linseed (flaxseed) oil are found to produced CLA levels that were similar to levels found in pasture fed cattle (Harris, 2001). However, diets with high oil percentage can adversely affect the digestibility of the feed and metabolism of rumen bacteria (Jenkins, 1993; Harris, 2001).

Since the majority of CLA is suggested to be endogenously synthesized by delta-9-desaturase, the most economical method to enhance CLA in milk fat may be to allow cattle to graze on green growing pastures, feed cows supplements containing *trans*-11-18:1 or management of rumen biohydrogenation through a special diet to increase the formation and accumulation of *trans*-11-18:1 (Griinari et al., 2000). It is important to note, that a pasture diet or a diet with elevated levels of linoleic acid and linolenic acid adversely affect milk fat content and possibly fat content (Khanal and Olson, 2004; Jones et al., 2005, Bauman and Griinari, 2003; Chouinard et al., 2001). Given that producers receive a milk price for each pound of milk component markets or the amount of milk components present per hundredweight of milk[4], milk producers should be financially compensated for the revenue lost from the reduction in milk yield and milk fat content experienced from producing CLA-enhanced milk. This implies that there is some level of CLA that would optimize milk production and lead to the highest economic benefit to dairy producers.

Market Potential for CLA-Enhanced Food Products

Numerous studies have investigated the health and market potential for CLA-enhanced dairy products. Parodi (2003) suggests that the "effective CLA" from the effective CLA intake is 140 to 420 mg/d which is within two to five-fold range of the estimated CLA intake needed to provide a health benefit. Findings from two different sensory studies by Lynch et al. (2005) and Jones et al., (2005) suggest that CLA-enhanced dairy products are not more susceptible to developing off-flavors from oxidation than the control milk even when oxidation was induced by light exposure and no off flavors were detected by untrained taste testers.

Functional foods are considered innovative new products. Innovation is defined as the development of something new or someone perceives the products as being new and it is believed to be the essence of economics in particular modern economics (Amanor-Boadu, 2005). Innovations change the characteristics of the market by using existing resources to create new products and services, developing new processes and products, and/or establishing new relationships in the market (Amanor-Boadu, 2005). Consumers' needs and preferences are considered to be driving forces behind innovation (Mark-Herbert, 2002).

The successful introduction of a new product to the marketplace requires effective pricing, advertising and other marketing programs. Choosing the product's selling price is one of the most important yet difficult decisions. The pricing objective of CLA-enhanced milk products is to attract new customers based on perceived health benefits; therefore firms should employ a premium pricing program.

Profile for Functional Food Consumers

Consumers have become increasing aware of the risk of certain health conditions as well as the risk associated with certain foods. Well informed consumers are seeking healthy alternatives to these unhealthy diets as well as proactive alternatives to decrease the risk of these health conditions. Functional foods present a unique solution to meet consumers' needs. However, the demand for functional foods is dependent on consumer's perception of health risks and their willingness to change their food habits and willingness to pay for a healthier product.

In general, women are more likely than men to be concerned about the health benefits associated with foods. Income and education are socio-demographic variables that are positively related to the belief in functional foods and their health benefits. Consumers aged 35-64 ages are more likely to believe in the health benefits of functional foods than consumers younger or older than this age group (Plaami, 2001, IFIC, 2005).

Another important aspect to the success of functional foods is the health claim or health message that is associated with the product. Consumers are more likely to understand and trust a health claim/message that is coupled with a brand name product (e.g., Becel Proactive and its ability to lower cholesterol). Thus, brand name companies should invest in functional food product lines. Interestingly, the majority of consumers are responsive to “soft” health message such as “for a better heart” or “your stomach will thank you”. Therefore, even though, scientific approval of a health product is needed to achieve a health claim for the product, scientific language is not needed to market the health product (Mark-Herbert, 2002).

Specific Conditions for Success

Thus far, we have reviewed the scientific literature and we have discovered that there is potential for a CLA-enhanced food product to help prevent certain cancers. We indicated it is possible to achieve such a product by feeding the dairy cows a specialty diet. Also, we have determined the profile of a functional food consumer. With these factors in mind, a firm will not introduce such a product unless there is a profit to be made. In order for a firm to be successful, specific product and market conditions must hold.

Condition One: The CLA-enhanced product must be priced appropriately with respect to its alternatives.

Even though, there are no set rules to determine the correct selling price, it is common practice to have a pricing strategy that is consistent with their marketing strategy. There are two main types of marketing strategies: primary-demand strategies and selective-demand strategies. Primary-demand strategies are associated with increasing the number of users or increasing the rate of purchase. In both cases, lowering the price may be able to achieve the desired strategy (Guiltinan et al., 1997).

The effectiveness of pricing programs in the selective-demand strategies is dependent on the value of the cross price elasticities between the different products. In the case of a firm seeking to expand their consumer base through additions to existing product lines, they must take into consideration the cross price elasticities between the existing products and the new products. If the cross price elasticity is positive, the probability of cannibalization of existing product sales is high. Moreover, if the cross price elasticity is positive and the new product is considered to be of "higher quality" than existing products, then a high price associated with the new product would signify the product's higher quality (Guiltinan et al., 1997).

Premium pricing refers to a price set above competitive levels. This pricing approach is successful if a firm can position its product on the inelastic company-demand curve either by differentiating the product in terms of higher quality, superior features or special services. Premium pricing can result in higher contribution margins as well as protection from price competition. The following are conditions that favor a premium pricing program: inelastic company demand; no excess capacity by the firm; strong barriers to entry; minor gains to economies of scale; and new customers are attracted by product quality (Guiltinan et al., 1997). The latter condition can be applied to the CLA enhanced milk product industry. The pricing objective of CLA-enhanced milk products is to attract new customers based on perceived health benefits; therefore firms should employ a premium pricing program. In order to gain the most revenue, firms should set the premium price so that its cross price elasticity is positive with respect to existing milk products. Therefore, consumers view the product as being a high quality substitute to existing milk products.

It is also important to price the CLA-enhanced milk product below pharmaceutical drugs that are designed to help treat and/or prevent certain types of cancers. It is likely that rational individuals would rather spend a portion of their income on less expensive customized food products than on expensive health care and medications to help maintain or improve their health. Since the firm is offering a lower priced food product that is of the same quality as expensive pharmaceutical drugs, which only a limited portion of the population can afford, more people will be willing to purchase the food product than the pharmaceutical drugs. Thus, the firm is able to gain a profit by receiving a fraction of the income that would have been spent on the pharmaceutical drugs because of the firm's consumer market.

Condition 2: Appropriate Target Market

According to Mark-Herbert and Nyström (2000), there are four market segments with different needs for functional foods. The largest segment is the "mass market" which refers to the average consumer who have no to little interest in functional foods. The next segment is the "prevention" segment. This segment consists of health conscious consumers who are interested in how foods and physical activity can affect their health. Consumers that are aware of a risk of developing a certain health condition (i.e., hereditary breast cancer) are more likely to change their diet and lifestyle to decrease their risk. These consumers represent the "at risk" segment. The final and smallest market segment is the "suffers" which consists of the consumers who have symptoms of a health condition and have the highest motivation to try a new health related product.

Since there is no direct cure for cancer, cancer prevention is of utmost importance especially among the population that considers itself at risk. Therefore, a proactive approach against the development of cancer is vital in maintaining a population's positive health status. This preventative market (includes the At Risk and Prevention market segments) is considered to be the best market for the CLA-enhanced food product. Within the preventative market, the firm will target the consumers that match the functional food consumer profile.

Firms will only enter into the functional food industry out of self interest to maximize their profits and not to serve for the "public good". Before a firm enters into the functional food industry, it must first determine the potential for profits, evaluate the costs involved, and develop a plan for distributing the profit between itself and others involved in the production process (i.e., laborers). Even though there is potential for large profits to be gained in the functional food and nutraceutical industry, the costs of developing, manufacturing, and marketing these customized food products may be high and could possibly outweigh the profits. Firms also must take into account the possible lengthy and costly regulation procedures that manufacturers must engage in to verify the safety and efficacy of the product before the product can be marketed. Thus, firms need to evaluate the cost-benefit ratio involved in entering into this new industry.

Given that there is a relatively new market area and that there is little information pertaining to the firms developing and introducing a CLA-enhanced food product to market, we must create a hypothetical case study to investigate our research questions. We have created a hypothetical firm, Healthy Dairy and we are using dynamic modeling techniques to conduct a feasibility study for Healthy Dairy entering into the functional food industry.

Method

Dynamic models allow for examination of supply chain responses to changes in the external environment. Continuum, dynamic models that are used to study supply chains are based on the System Dynamics (SD) methodology developed by Jay Forrester. SD is an interdisciplinary analytical tool which models the interrelatedness of system forces using the concept of feedback. These feedbacks allow researchers to see how actions can reinforce or counteract one another (Senge, 1990). Due to the nonlinear complexity of supply chains as well as the feedback among the partners in the supply chain, SD methodology is a useful tool to model and analysis the behavior of supply chains (Carlevaro et al., 2004). Stella® is the computer program used in this study.

SD is fundamentally different from empirical approaches such as historical analysis, optimization analysis, and econometrics. Unlike these traditional approaches, data collection does not play a dominant role in SD models. This is one of the primary reasons why SD was chosen as the modeling program used in this article. Despite the lack of historical data associated with this research topic, SD is able to adequately model the socio-economic relationships involved in this research thesis topic.

SD is a scenario analysis tool not an optimization tool and it is driven by assumptions. The modeler is forced to specify the assumptions in order to gain a better understanding of the world. SD projects how the future world would behave under different scenarios. Thus, it does not choose the optimal result but presents various scenarios of what the future may look like.

In this article, SD methodology has been used to study a specific agri-food chain in order to describe its operation. The agri-food chain under investigation is the functional food industry - more specifically CLA-enhanced cheese - in the United States. Cheese was chosen as the dairy product because CLA is a fatty acid and it can be effectively enhanced in high fat milk products. Also, the cheese industry was chosen due to the fact that American cheese consumption has doubled since 1975. According to ACNielsen, total cheese sales for the year ending April 16, 2005, were $9.2 billion in food, drug, and mass merchandising stores, which represents a 7.9 percent increase from the previous year (Liebeck, 2005).[5] In 2004, the per capita consumption of cheese was approximately 31 pounds (ERS, 2004). Therefore, cheese is an ideal food product because of it high fat content and its increase in popularity with American consumers.

Model

In order to develop a model that represents the complexity of the real world, assumptions are needed. These assumptions are critical in (1) creating an abstraction from reality that is as close to reality as possible and (2) increasing our understanding of the relationships of the real world as much as possible.

As previously mentioned, Healthy Dairy is a hypothetical dairy product manufacturer with keen interest in developing a supply chain to bring Avert®, a CLA-enhanced cheese to market. Avert® is a versatile product and its regular consumption that is known to improve a human's health status by reducing the incidence and/or improving the symptoms of cancer. Presently, Healthy Dairy manufactures traditional cheese and skim milk powder at one processing facility strategically located in the South Central Valley in California close to milk producers. Currently, Healthy Dairy has approximately 0.004 percent of the market share. This implies that Healthy Dairy does not have market power to change or shift the market or its prices.

In producing Avert®, Healthy Dairy requires its milk suppliers to produce CLA-enhanced milk. For this, Healthy Dairy is willing to pay a premium based on the concentration level of CLA in the milk. To help producers achieve the level of CLA enhancement in their milk, Healthy Dairy will specify the feeding regime and nutrition requirements that producers must follow as part of their contract.

The product will be first launched in California because it provides an ideal test market given its large population base and its consumers' attitude towards healthy food products. California consumers are believed to be highly responsive to public health campaigns and fad diets (e.g., California 5-a-Day Campaign) and are generally more health-conscious compared to the rest of the American population (California Department of Health Services, 2004). The focus on California is assumed to last two years, after which Healthy Dairy expects to expand its market to the rest of country in a systematic manner of growing market share through targeted penetration.

Since the adoption of new technology or product is dependent on need, it is assumed that only people who believe they are at risk of developing the three health conditions will be interested in Avert®. This group does not include those who already suffer from the health condition since it is assumed that they will need to take their medication in order to benefit from their therapeutic effects instead of consuming Avert® for its prophylactic effects. It is assumed that the group consuming Avert® for it prophylactic benefits will consist of people aged 25 to 84, who do not yet have any of the health conditions, based on the principle that early consumption of CLA-enhanced cheese is an effective way to prevent the onset of these health conditions. The population is divided in to ten-year cohorts (i.e., 25-34, 35-44, etc.). The risk associated with developing these health conditions varies among the different cohorts and generally, the risk increases as age increases. Adoption of Avert® is assumed to follow the Rogers adoption path that many other types of innovations, new ideas, products and practices. The adoption path is based on the idea that innovative ideas, products, and practices are not adopted by all members in society at the same time.

Healthy Dairy's target market is based on the aggregated population of males and females who do not have any cancer and who will purchase Avert® as a preventative method. It is predicted that Healthy Dairy's contribution to the market will reach about 10 percent of the consumers in the target market.

We have assumed that females and individuals earning an annual income of $75,000 USD or more are more likely to purchase functional foods than males or individuals earning an annual income less than $75,000 USD (IFIC, 2005). Also, even though people at risk of developing these health conditions are more likely to consume CLA-enhanced cheese, only a certain percentage of these people will actually purchase CLA-enhanced cheese.

We have also assumed that consumers have high brand loyalty and their degree of brand loyalty increases with income. Therefore, it is assumed that once consumers switch to Avert®, they will continue to be loyal to the brand for the duration of the analysis. Another assumption is that the majority of households will purchase only one brand of cheese. Since females are the main household purchasers of food and they are more likely to purchase Avert®, it is assumed that Avert® will be the cheese purchased for the household.

Importantly, it is assumed that the individuals in the target market are not the same Avert® consumers every time. Realistically, Healthy Dairy does not anticipate each individual in its target market to consume three servings of Avert® a day. However, Healthy Dairy is assuming that, collectively as a group, individuals in the target market will consume the daily recommended amount of Avert® cheese in order to meet the target cheese consumption determined by Healthy Dairy (i.e., 0.28 pounds of Avert® cheese per day).

Because of its contribution to health status improvement, Avert®, is being presented as a competitor to pharmaceutical products that provide similar value propositions to consumers. Healthy Dairy's pricing of Avert® is structured to reflect its real market competitors without losing sight of their potential to increase market share through strategic market penetration. Therefore, Healthy Dairy plans to price Avert® above traditional cheese but below the price of pharmaceutical products targeting the disease of interest of Healthy Dairy. The following relationship is the basis for Avert®'s pricing scheme:

$P_0 \leq P_A \leq P_P$ where P_0 is the traditional cheese price, P_A is Avert®'s price and P_P is the weighted average price of leading pharmaceutical products for breast and prostate cancer – Tamoxifen and Casodex. It is important to recognize that the benefits of Avert® captured by this pricing method are underestimated. Through consumption of Avert®, which has no known medical side effects, consumers are preventing the onset of cancer without experiencing any of the unpleasant side effects of the pharmaceutical drugs. Also, the costs stated for the pharmaceutical drug are the accounting costs (i.e., out of pocket costs) and are not the total economic costs associated with these drugs (e.g., the cost of loss of productivity). Although Healthy Dairy recognizes the importance of the economic cost of the competing products, it consciously uses the out-of-pocket costs as the benchmark in pricing Avert®.

Healthy Dairy will manufacture Avert® from raw milk received by their contracted milk producers and distribute Avert® cheese to its retail partners. A premium of $0.05 per pound of milk will be paid to milk producers for milk that contains the specific level of CLA required by Healthy Dairy. Otherwise no premium will be paid to producers, and instead the premium will be used to purchase CLA supplements that will be added to the cheese to ensure that the end product will contain the specific level of CLA.

Revenue generated by the processing facility is from sales of Avert® cheese and possibly from the sales of nonfat skim milk. From 1998 to 2004, the average US retail price for 40 lb cheddar cheese (traditional cheese) was $1.37 per pound, assuming a 40 percent mark up factor (NASS, 1998- 2005). Thus, a processor will typically sell traditional cheese for $0.833 per pound. The premium received by processors is dependent on the processing costs especially the input costs (i.e., cost of CLA-enhanced milk).

Costs associated with the processing facility are from the purchases of raw milk from dairy producers, processing costs associated with CLA-enhanced cheese and possibly skim milk powder and transaction costs associated with developing contracts with producers. As mentioned above, the cost of raw milk is highly dependent on its CLA content. The cost of purchasing CLA supplements is part of the processor cost. The cost of CLA supplement is determined by multiplying the CLA deficiency (the amount of CLA supplement required to meet the standard CLA amount per pound of milk) by the CLA supplement price. The CLA supplement price is based on $0.05 multiplied by the ratio of CLA deficiency to the standard CLA amount.

Given that ten pounds of CLA-enhanced milk is needed to produce one pound of cheese. Therefore, ten pounds of CLA-enhanced milk will cost processors more than $1.36 to produce one pound of cheese. Data from 1989 to 2004 estimates the weighted average manufacturing costs[6] for a Californian cheese processing facility to be $0.1726 per pound (Department of Food and Agriculture, 2004). Included in this manufacturing cost are marketing costs. As Healthy Dairy enters into the national market, intensive marketing campaigns are needed to attract more consumers. Even though, Healthy Dairy is benefiting from economies of scale when processing the high volume of milk to satisfy the national target market, these scale benefits will be absorbed in the higher marketing costs. Also the interest on capital investment is implicit in the manufacturing costs. To simplify the modeling process, a Cobb Douglas production function (i.e., constant returns to scale) was assumed.

The production segment is based on individual dairy operation(s) in South Central Valley, who all share a common objective to maximize their profits by producing high valued CLA-enhanced milk. Each one of the dairies is a representative of an average dairy operation in South Central Valley. Based on historical data and industry predicted (Blayney, 2002), the growth rate for dairy herds is 4.52 percent per annum. This rate is assumed to prevail among the contract farms. Given that the average annual cull rate for a dairy operation is 38 percent as suggested by Dr. M. Brouk from Kansas State University, this implies that the annual replacement rate for herd development is set at 42.52 percent.

Recall, Healthy Dairy stipulates that their dairy producers feed the dairy cows a “special diet” consisting of 55 percent forage, 43 percent corn and two percent linseed. The amount of milk produced per cow is a function of the feed ration and the feed to milk efficiency which is a function of breed. The average Californian cow produces approximately 68 pounds per day (i.e., approximately 24,000 pounds of milk per year) (Genske, 2005). In general, a milking cow that produces 68 pounds of milk per day consumes approximately 50 pounds of feed per day (CANWEST DHI, 2005).[7] The feed-to-milk efficiency for a cow possessing these production characteristics is within the range of 1.232 to 1.408 pounds of milk per one pound of feed consumed (CANWEST DHI, 2005).

The following equations are indirect and direct relationships that influence total milk production: $Milk\ Productivity = f(CLA\ content, genetics)$ and $Yield = f(milk\ productivity, number\ of\ cows)$. Let milk composition, c, given by $c = f(CLA\ Content)$, where milk composition (i.e., milk fat content) is negatively affected by CLA content. Also, it is assumed that the CLA content cannot be predicted ex ante. CLA itself is influenced by genetics and diet. $CLA\ Content = f(genetics, feed\ quality)$

Total revenue generated by a dairy operation is equal to the revenue earned from milk production and selling culled cattle. Expenses for a single dairy operation include the cost of replacing cattle to support herd development, feed costs, and other operating costs.

In figure 1, A Causal Loop Diagram (CLD) is used to illustrate the relationship and feedback structure of the Healthy Dairy's supply chain. The arrows in the diagrams represent the relationships between the system components and the signs above the arrow indicate the direction of the effect with respect to the cause (Carlevaro et al., 2004).

Results

Along with the base scenario, two other alternative scenarios were analyzed. Scenario 1, an internal scenario, presents a situation in which Healthy Dairy can control while Scenario 2, an external scenario, is outside of its control. In Scenario 1, we assume that Healthy Dairy's premium will decrease from 50 percent to 20 percent over the ten year period, in response to a demand price pressure exerted by competitors. Since Healthy Dairy has positioned Avert® as a premium product, purchasing rights based on their position the demand price pressure is expected to make Healthy Dairy unprofitable under this scenario.

Recall that under the base scenario, the daily recommended amount of Avert® is 0.28 pounds. Under Scenario 2, we assume that individuals in the target market, collectively as a group, only consumer two-thirds the daily recommended amount of Avert®. The target cheese consumption is expected to be smaller in Scenario 2 compared to the base scenario.

Base Scenario

The discounted revenue for Avert® sales over the 10 years at 8 percent was $2.24 billion with a discounted cost of $1.57 billion. The net present value (NPV) of Healthy Dairy's profit stream over the 10 years was $665 million. Producers supplying milk to Healthy Dairy realized a total discounted revenue of $1.39 billion over the period and cost of $910 million leading to a profit of almost $480 million over the ten years.

Figure 3 represents the average annual cheese price received by Healthy Dairy and the impact of these prices on their profit per pound of cheese and figure 4 represents the impact of milk prices paid by Healthy Dairy to its producers on the producers' profits per pound of milk. It is obvious from figure 3 that there is a strong positive correlation between Avert® price and unit profit of cheese (correlation coefficient of 0.98). Therefore, Healthy Dairy's profits are very dependent on the price that they receive for Avert® price. We therefore explore the explanatory power of price on profit. This will help determine the critical role of price for Healthy Dairy and its producers. Using a single linear model, we estimated profit per pound of milk and cheese as a function of the price of milk and cheese. The results are presented in equation (1) and (2) respectively.

$$\pi_1 = 0.01583 + \underset{(1.12)}{0.17586}\, P_{MK} + e \qquad \textbf{(1)}$$

F-stat = 1.25

$$\pi_2 = -0.68897 + \underset{(14.53)}{0.60005}\, P_A + e \qquad \textbf{(2)}$$

F-Stat = 211.0

where π_1 represent producers' profit per pound of milk, π_2 represents Healthy Dairy's profit per pound of Avert® cheese, P_{MK} represents price per pound of milk and P_A represents price per pound of Avert®.

In equation 1, the milk price is insignificant at the 5 percent significance level. From the equation, a $1 increase in P_{MK} will result in a $0.18 increase in π_1. In equation 2, P_A is significant at the 5 percent significance level and it explains a $1 increase in P_A will result in a $0.60 increase in π_2. The foregoing suggests that Healthy Dairy's profit is more dependent upon the price of their product (i.e., Avert®) than producer's profit is on milk price. This may be explained by the fact that producers have alternative outlets for its CLA-enhanced milk, such as forfeiting their CLA milk premium and selling the milk on the traditional milk market; Healthy Dairy has designed its product and marketing strategy to one specific market – the CLA-enhanced food market. Therefore, unlike producers, Healthy Dairy has a very limited number of alternative markets in which Avert® could be sold. Producers have the opportunity to focus on cost minimization, instead of price maximization as a strategy. Healthy Dairy, on the other hand, has focused all on its manufacturing and marketing efforts towards the success of Avert® and has limited its opportunity to minimize costs without adversely affecting the value proposition of Avert®. Thus, Healthy Dairy's profit strategy centers on its ability to maximize the price of Avert®.

Scenario 1

In the base scenario, we have shown that price is a very significant variable in the profitability of Healthy Dairy. With this in mind, Scenario 1 explains the effect of premium pressure on Healthy Dairy's performance by reducing the premium from 50 percent to 20 percent over the ten year simulation period.

Producers' profit decrease by 8.07 percent to a NPV of nearly $442 million compared to the base scenario (table 2). Producers also experienced a 0.49 percent decrease in their revenue and a 40 percent decrease in their costs in comparison to base scenario parameters. Healthy Dairy's profit decreased by 68.31 percent to a NPV of $211 million in comparison to the base scenario. The NPV of Healthy Dairy's revenue fell 20.63 percent from the base scenario but its cost slightly decreased by 0.43 percent. Despite this significant decrease in profits, Healthy Dairy was able to earn positive profits under this scenario. Interestingly, the producers are more profitable than Healthy Dairy under these market conditions.

Scenario 2

In Scenario 2, we assume that consumers are consuming two-thirds of the daily recommended intake. However, Healthy Dairy is producing enough Avert® to meet the daily recommended intake for the target market. Therefore, there is an excess supply of Avert® in the market. We assume that Healthy Dairy will market the excess supply of Avert® to the traditional cheese market. Under this scenario, the NPV of processor's profit decreased by 44 percent to about $372 million while producers' profit decreased by 7.50 percent to $444 million (table 3). During the ten year period, the total target Avert® consumption decreased by 33.36 percent over the base scenario parameter.

Summary of Results

The analysis suggests that Healthy Dairy can be competitive in the functional food market if the company satisfies the proposed conditions. The two main conditions are market size and price, with the latter being the most critical to the feasibility of Avert®. With respect to the market size condition, Healthy Dairy must focus their efforts on ensuring it is reaching the largest population possible and encouraging them to purchase Avert®. We suggest that Healthy Dairy must effectively manage variables within their control and minimize the adverse impacts of external variables. To this end, we suggest that Healthy Dairy focuses on two principal areas of strategy: production and market relationship. Specifically, it must ensure that it is operating as efficiently as possible within the cheese processing segment of the supply chain.

It is important for Healthy Dairy to enhance its market penetration activities through collaboration with cancer organizations. For example, Healthy Dairy must work with American Cancer Society to educate the public and increase its awareness about the usefulness of functional foods such as Avert® in combating cancer. Simultaneously, Healthy Dairy must work with the Food and Drug Administration to secure a health claim for Avert®.

Given the importance of pricing, Healthy Dairy must establish a price that will attract the largest group of consumers as well as generate sufficient revenue to more than cover the company's costs. To achieve this, Healthy Dairy prices Avert® at a premium above the price of traditional cheese but below the price of pharmaceutical cancer drugs. Healthy Dairy will target to the health-conscious consumers in its pricing, presentation, and marketing of Avert®. In addition to these pricing and marketing factors, Healthy Dairy's success also depends on maintaining a high level of operational efficiency in its processing activities.

Limitations and Suggestions for Further Research

In this article, we researched three scenarios for this hypothetical firm. The scenario contained realistic market conditions in which we thought that the firm could achieve. For simplicity and efficiency sakes, we omitted certain components of the supply chain (e.g., retail segment) and did not explicitly capture its activities (e.g., double marginalization on the price of Avert®). Another limitation of the model is that a Cobb-Douglas production function was assumed throughout the article. The effects of this assumption could have been reflected in the absence of scale effects resulting from the changes in market size and productivity in the model. The challenge of finding specific cost data on some of the cost items by location forced us to bundle cost into total operating cost at both stages in the Avert® production process, i.e., CLA-enhanced milk and CLA-enhanced cheese.

We believe these constraints influenced the results by making them conservative. For example, relaxing the constant return to scale assumption would enhance the profitability of the operation than was observed. Also, unbundling costs would allow us to determine the principal cost effects on profitability besides feed costs at the production level and milk costs at the processing level.

Finally, we assumed that those consuming Avert® achieved the results they expected, i.e., health status improvement. Further research may relax this assumption and assess the profitability implications for post-marketing efficacy effects (Amanor-Boadu, 2005) for this functional food product. Future research may investigate the feasibility of Avert® for Healthy Dairy under different market conditions. Since the Healthy Dairy's profits are sensitive to pricing of Avert® , a scenario determining the breakeven price for Healthy Dairy would be worth investigating.

Conclusion

The purpose of this research was to determine the economic feasibility of introducing Avert® into a target market comprising of consumers interested in preventing the onset of certain types of cancer – breast and prostate. It also investigated the alternative scenarios that could confront Healthy Dairy once it entered the market and their effects on the economic feasibility of the introducing Avert®. The results allowed us to develop some strategic options for Healthy Dairy to minimize the adverse impacts and enhance the positive impacts of the alternate scenarios.

A system dynamic modeling approach provided an effective tool to effectively conduct scenario analysis for Healthy Dairy's imitative to introduce Avert® to market. It allows the modeling of alternative assumptions and capturing of the results for comparisons and analyses. More importantly, it allows management to understand the direct, indirect and seemingly unrelated relationships among the different factors that affect performance.

The results suggest that it is feasible to introduce Avert® into the market provided Healthy Dairy develops a production and marketing system that reflects the assumptions we presented. The prevent value of total chain profits – processor and producers – under the base scenario were estimated at $1.1 billion. To test the robustness of the feasibility of Avert® in the market, we evaluated the profits under two alternative scenarios – a decrease in premium price and a decrease in quantity of Avert® consumed by individuals in the target market. The results showed that the product was robust under these market conditions. However, Healthy Dairy was the least profitable when the premium on Avert®'s price drops dropped to 20 percent. This suggests that the market feasibility of this particular product is extremely sensitive to market prices. Thus, Healthy Dairy needs to ensure that it can extract high enough premiums from the market if it is going to differentiate itself enough from the commodity market to secure a profitable return on its operations. Given the importance of the premium for Avert® on Healthy Dairy's profits, it is strongly recommended for future research to identify the premium that leads to negative profits for Healthy Dairy.

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Appendix A

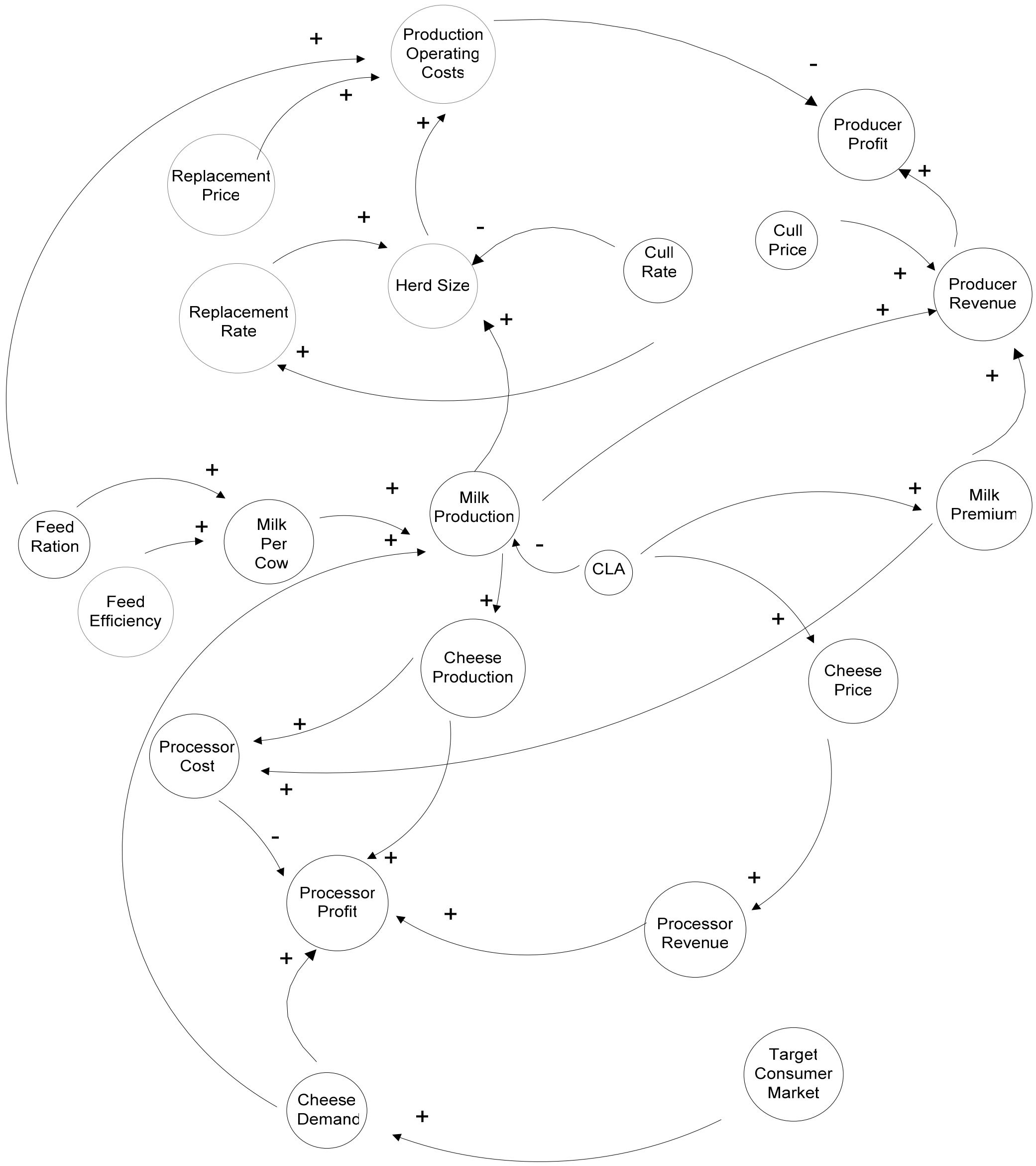

Figure 2.Casual loop diagram of Healthy Dairy's supply chain

Table 1. Discounted Economic Results of Base Scenario

Model Parameters	Base Scenario ($ Millions)
Producer Level	
Revenue	1,390
Cost	910
Profit	480
Processor Level	
Revenue	2,235
Cost	1,570
Profit	665

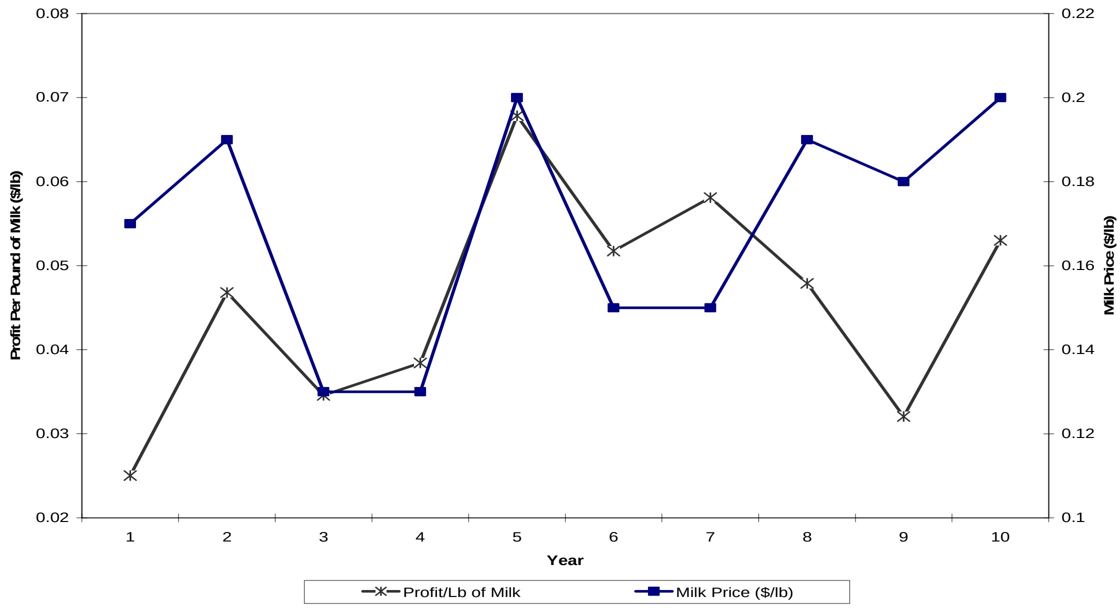

Figure 3: Producers’ profit and milk price per pound

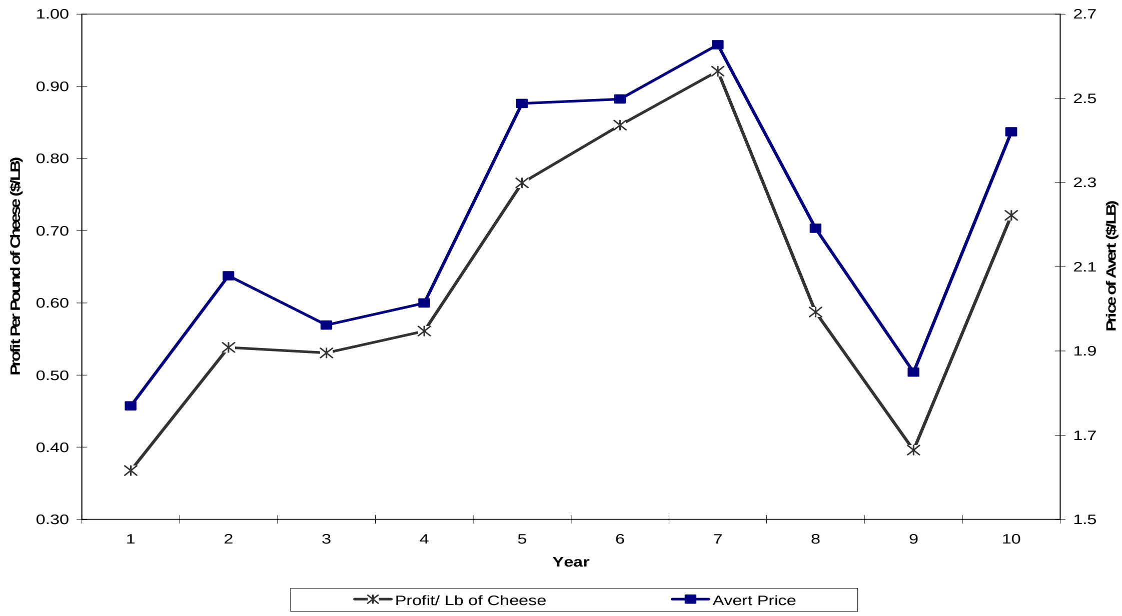

Figure 4: Processor’s profit per pound of cheese produced

Table 2. Discounted Economic Results of Scenario 1

Model Parameters	Scenario1 ($ Millions)	Percentage Change from Base Scenario
Producer Level		
Revenue	1,384	-0.49%
Cost	943	3.51%
Profit	442	-8.07%
Processor Level		
Revenue	1,773	-20.63%
Cost	1,563	-0.43%
Profit	211	-68.31%

Table 3. Discounted Economic Results of Scenario 2

Model Parameters	Scenario 2 ($ Millions)	Percentage Change from Base Scenario
Producer Level		
Revenue	1,380	-0.73%
Cost	936	2.84%
Profit	444	-7.50%
Processor Level		
Revenue	1,932	-13.54%
Cost	1,560	-0.64%
Profit	372	-44.0%

[1] Adipose tissue is the connective tissue in ruminants that stores fat cells

[2] Pulmonary tumor burden refers to the size of the tumor or number of cancer cells present in the lung.

[3] Uncontrolled cell proliferation is a key sign of cancer in the body.

[4] In the federal milk order program, producers are paid a price for each pound of milk component marketed as well as the producer priced differential (weighted average value of the effective Class I and Class II differentials.   In California, minimum hundredweight price is established based on the milk components.

[5] Cheese sales from Wal-Mart are excluded from the Total Cheese sales.

[6] Weighted average manufacturing costs include processing labor, non-labor processing, packaging, other ingredients, general and administrative and return on investment costs.

[7] A cow that consumes 50 pounds of total dry matter intake produces 61.6 to 70.4 pounds of milk per day