Decision and Risk Analysis in a New Product and Facilities Planning Problem

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Risk analysis was originally presented as a useful addition to the range of techniques used in financial evaluations. It was seen as a logical extension to sensitivity analysis and as a means of explicitly taking account of uncertainty in financial forecasts. The proposition that risk and uncertainty could be more accurately defined by a simulation of input variables became widely accepted. It was emphasized, however, that risk analysis was a strategic decision aid and that eventually managerial judgment would be required in both input estimation and decision.

Although some readers saw this as an argument about methodology in investment appraisal, that was not the main intention. Rather, the aim was to alert businesspeople about the need to examine carefully the data and assumptions surrounding decision problems, given the pervasive uncertainties in both business and other environments.

Broader uses of the techniques of risk analysis have been explored in recent literature. For example, risk analysis is increasingly seen as a necessary and useful adjunct to a strategic planning and thinking process. It is viewed as an approach for forecast/uncertainty based planning (Stage IV/III of Gluck’s four stages of strategic planning), in which an understanding of project risk, cash flow projections, and future scenarios is developed.

Underlying this article is the suggestion that risk analysis can also help strategic thinking by encouraging constructive dialogue and debate about policy options. In such a dialogue process, risk analysis is an input for the strategy development process, aiding strategy formulation, evaluation, choice, and implementation. No distinction is drawn between strategic risk analysis and strategy formulation. Instead, both are viewed as parts of an iterative, adaptive, and flexible policy dialogue process. This dialogue involves the consideration by management of problem and policy formulation through a continual reexamination of potential alternative strategies and problem assumptions.

The role of strategic risk analysis in policy formulation and choice should, therefore, be to encourage serious thinking about the problem under consideration. The analysis should highlight the alternatives to be considered, examine the changing secondary effects, and anticipate the nature and extent of the impact of uncertainty for contingency planning. Nevertheless, it must be recognized that an initial risk analysis is no more than a first attempt at problem understanding. Its role should be to encourage controversy and to allow members of the decision-making group to discover where basic differences exist in problem assumptions, values, and uncertainties. This controversy should enable critical comment and review to be obtained, and should force the reanalysis, reexamination, and sensitivity testing of the problem solution. It is hoped that, after considerable dialogue, the quality and level of debate should facilitate compromise and consensus around a reasonable problem solution.

This article discusses the role of risk analysis in relation to a potential investment opportunity in the plastic egg carton market. The problem is somewhat disguised in regard to project chronology and magnitudes...
of input data, but the problem structure and new product area are unaltered.

The risk analysis approach involved three groups: the management at ABC (disguised company name), the ABC project team (charged with the responsibility for project evaluation), and the consultants (providing technical expertise and guidance). Various decision alternatives were considered, ranging from abandonment to expansion strategies. Abandonment would involve the loss of the pilot plant; expansion strategies would involve both the larger plants (known as superplants) and a series of smaller plants.

This article illustrates the step-by-step nature of the application of risk analysis and describes the procedures adopted at each stage of the analysis. The problem structure is developed in flow diagram form, and the problem assumptions are stated. This is followed by an initial sensitivity analysis where investment alternatives are developed, subjective probabilities are assigned, and the results of the risk analysis are presented. Finally, the article outlines the process of policy dialogue about the strategy to be chosen and summarizes the conclusions.

The Egg’N Foam Project

The Egg’N Foam project at ABC involved a large number of issues. The project represented a large investment in a new market area and a new product for ABC. For several years ABC had been developing Egg’N Foam, a plastic package produced as a competitive substitute for paper egg cartons. The product design had been refined, and a pilot plant in Pennsylvania had been operational for some time. Still, the project involved substantial amounts of uncertainty.

The project team selected to work on the Egg’N Foam decision consisted of representatives from the Research and Development Division, the Plastics Division, and the Corporate Controller’s Office. Those involved had been associated with the Egg’N Foam project for a considerable period of time, and were familiar with the development, production, and marketing aspects of this project. This team used the step-by-step approach described below to study the attractiveness of investing more funds in Egg’N Foam.

The Risk Analysis Process

Developing the Flow Chart and Problem Structure

The first step in applying risk analysis to the Egg’N Foam project was to construct a flow chart of the investment analysis. The process started with an assessment of the basic economics of the investment project; each element was entered in a simple chart. The initial Egg’N Foam flow chart shown in Figure 1 consisted of six elements: the total market size for egg cartons, ABC’s foam market share, the selling price, the manufacturing cost, total overhead, and the investment base.

The initial flow chart was then expanded backward to encompass a large set of input factors. This involved establishing a value for each factor and analyzing the determinants of that value, questioning the validity of the determining factors, and, where possible, exploding the elements into further detail. The final product was a flow diagram of all the factors relevant to determining the profitability of Egg’N Foam.

The final flow chart for Egg’N Foam was considerably more detailed than the initial chart. The manufacturing costs, overhead costs, and investment base were all expanded into a substantial number of inputs. However, the unavailability of sufficient market data limited the amount of analysis which could be undertaken on the marketing elements (i.e., market size, market share, and price).

Stating the Assumptions

When the flow chart was completed, assumptions underlying each of the factors were stated explicitly and recorded. This step was particularly important, because it placed a limit on the amount of detail required to substantiate the data inputs. For
example, if the project team assumed ABC would capture a 10 percent share of the carton market, little data would be needed to estimate ABC’s sales volume.

Once assumptions have been stated, however, it is necessary to verify their reliability. Because invalid assumptions can result in misleading and inaccurate conclusions from analytic models, verification, and questioning of assumptions is an integral and important part of this phase of the analysis.

The Egg’N Foam project team was able to verify the validity of most of its data, including information about equipment rates supplied by Research and Development Division personnel, and forecasts of total egg production supplied by the U.S. Department of Agriculture. However, further study was considered necessary to determine the accuracy of some of the data and assumptions. In particular, more specific information was required about the percentage of eggs cartoned and future Egg’N Foam sales volume and price.

Analyzing Sensitivity

The next step in the analysis was to construct a nonprobabilistic computer model based on the flow chart. The model was built for a single plant, as each region represented a similar size market that would support a single plant operation. The model performed all the calculations indicated by the flow chart and provided answers in terms of the return on investment and cash flows.

The model was also used to determine the sensitivity of investment returns and cash flows to changes in input variables. The team could pose such questions as: “What would happen to the discounted rate of return if the price dropped by $0.50 per thousand cartons?” or “What would happen if, say, the thermoformer cycle time (in the production process) were improved to 4½ seconds?”

The results of the sensitivity analyses on Egg’N Foam are shown in Figure 2. Changes in two factors, caliper (or thickness) and demand, had a dramatic effect on the rate of return, whereas changes in the value of other factors had only a minor impact on profitability. The high sensitivity of the investment return to changes in caliper and demand indicated the extreme importance of the accuracy of the assumed sales volume of Egg’N Foam.5

The sensitivity analysis was also valuable in identifying the optimal plant operation. It permitted the team to use the computer to experiment with different equipment combinations and plant sizes. When applied to Egg’N Foam, the sensitivity analysis suggested that one extruder could support two thermoformers instead of one thermoformer. The analysis also demonstrated the feasibility of building larger plants containing two extruders and four thermoformers.
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<table>
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<tr>
<th>Figure 2</th>
<th>Sensitivity of Investment Return to Changes in Major Input Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base Case:</strong></td>
<td>Extruder Rate = 525 lb./hr.</td>
</tr>
<tr>
<td><strong>One Extruder</strong></td>
<td><strong>One Thermoformer</strong></td>
</tr>
<tr>
<td><strong>Caliper = .080 in.</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Factor</strong></td>
<td><strong>Change</strong></td>
</tr>
<tr>
<td>Extruder Rate</td>
<td>525 to 625 lb./hr.</td>
</tr>
<tr>
<td>Thermoformer Cycle Time</td>
<td>5.3 to 4.2 sec.</td>
</tr>
<tr>
<td>Raw Material Costs</td>
<td>15.0¢ to 13.5¢/lb. pellets</td>
</tr>
<tr>
<td>Equipment Costs</td>
<td>$790,000 to $990,000</td>
</tr>
<tr>
<td>Caliper*</td>
<td>.080 to .100 in.</td>
</tr>
<tr>
<td>Demand</td>
<td></td>
</tr>
<tr>
<td>From</td>
<td>21</td>
</tr>
<tr>
<td>To</td>
<td>21</td>
</tr>
<tr>
<td>Price</td>
<td>Decreased 50¢</td>
</tr>
<tr>
<td>Direct Labor</td>
<td>Extruder</td>
</tr>
<tr>
<td></td>
<td>Thermoformer</td>
</tr>
</tbody>
</table>

*Caliper increase reduces physical capacity of plant considerably. 
*Sales volume drops from 76 to 66 in year 3. 
*Adjusted to use one extruder to two thermoformers.

Developing Investment Alternatives
After the sensitivity analysis was performed, the single plant model was used as a building block in constructing investment strategies for Egg'N Foam. The team developed four alternative strategies for ABC in the egg carton market; these strategies are shown in Figure 3 and are expressed in terms of the timing and sequence of equipment installation by plant location. Two strategies involved building superplants, each containing two extruders and four thermoformers; the other two strategies called for small plants, each containing one extruder and two thermoformers.

The difference between the two superplant strategies and the two small plant strategies is speed of market entry. The slow, conservative investment pace suggested for both small and superplants required the addition of thermoformers only after the demand for the output of existing equipment was firmly
Figure 3  Egg’N Foam Investment Strategies

Superplant Strategy
Number of Thermoformers

Key:
MW = Midwest
SW = Southwest
NE = Southeast
SE = Northeast

Fast

Slow

Total Investment = $8 Million

Small Plant Strategy
Number of Thermoformers

Fast

Slow

Total Investment = $8 Million
established. The fast investment strategies assumed that ABC would act as quickly as possible to acquire equipment, to hire and train the necessary manpower, and to open the plants.

Assigning the Probabilities
The team next obtained probability information for values of input factors. Subjective probabilities were developed for the five inputs to the model that had either a significant impact on profitability or a considerable degree of uncertainty. Three of these inputs related to the production process (extruder rate, thermoformer cycle time, and caliper), and two were marketing variables (price and demand). The probability distributions were obtained using the fractile assessment method suggested by Raiffa, and represented the best judgment of ABC personnel who were most knowledgeable about the Egg‘N Foam project.*

The CDF Method. Raiffa’s fractile assessment procedure, sometimes called the CDF (cumulative distribution fractile) method, has found considerable acceptance as an approach for assessing subjective probability distributions.* The horizontal axis of the cumulative distribution (CDF) shows possible values of the uncertain quantity, X (e.g., price of the new product), and the vertical axis gives the probability that the true value is X or less.

The following example demonstrates the implementation of this approach. It illustrates the actual assessment of the probability distribution for the price per thousand Egg‘N Foam cartons for the first year of the new product launch. The series of questions might be as follows:

— Analyst: Can you give me a value of the price (per thousand cartons) such that you feel there is only a very small chance, say 1%, that it will be exceeded during the first year of the Egg‘N Foam launch? (Note that this establishes the value at which the CDF = 0.99.)

— Manager: I guess I would say $27.

— Analyst: Can you also give me a value of the price (per thousand cartons) such that you feel there is only a very small chance, say 1%, that it will be below that value during the first year of the launch? (Note that this establishes the value at which the CDF = 0.01.)

— Manager: There is no way that it would go below $22.

— Analyst: Can you give me a value for price that you feel has a 50% chance of being exceeded during the first year? (Note that this establishes the point at which the CDF = 0.50.)

— Manager: Now, that’s a hard thing to conceive. I suppose about $25.

— Analyst: Are you sure about that? Would you find it extremely hard to choose between a bet on the interval above $25 ($25–$27) and on the interval below $25 ($22–$25)? (Note that this is a consistency check to ensure that $25 is the 0.50 fractile or the 50th percentile of the distribution.)

— Manager: Yes.

— Analyst: Now, suppose that the actual price during the first year will be below $25. Can you give me a value for price in the range of $22–$25 that you feel has a 50% chance of being exceeded?

— Manager: Say $24. (Note that this establishes $24 as the 0.25 fractile, i.e., the value of price at which the CDF = 0.25.)

— Analyst: Finally, given that the true value of the price during the year will exceed $25, can you give me a value for price that you feel has a 50% chance of being exceeded?

— Manager: Well, I guess that I am beginning to understand what you are after now. My indifference point is about $26. (Note that this establishes $26 as the price at which the CDF = 0.75.)
From the set of five discrete points (namely, the 1%, 25%, 50%, 75%, and 99% fractiles) obtained from these questions, an approximate curve for the CDF can be drawn, as shown in Figure 4.

It is perhaps important to stress that, although the probability assessors felt confident about their short-term forecasting abilities (for, say, the next three years), they had some difficulty in thinking about future events (over a three- to ten-year horizon) which would impact upon their longer-term assessments. Therefore, in order to structure their thought processes, certain assumptions were made that were the basis for their probability assessments over the ten-year period.

In the case of the three production variables, it was assumed that technological and design advances would improve the performance of extrusion and thermoformer equipment and would enable caliper thickness to be better and more uniformly controlled. It was anticipated that such new equipment would be introduced approximately two to three years after product adoption.

In the case of the assessment of marketing variables, much stronger assumptions were made. Based on current evidence, it was felt that the price of a carton would decline linearly in real terms over the time horizon. Estimates of demand were based on the assumption that ABC would be able to capture a 10 percent market share in six years with the fast strategy or in ten years with the slower strategy.

**Risk Analysis, Capital Asset Pricing, and Project Appraisal**

A weakness of the risk analysis approach is that it provides narrow, uncertainty-based information on the project’s business risk and little or no information on the relationship between the project and the portfolio of risks faced by the company (or investor). It is, therefore, helpful to use the capital asset pricing model (CAPM) to assess the viability of the strategy alternatives associated with the project. The first step is to estimate the company’s cost of equity capital that can then be used, assuming minimal debt, as the discount rate in capital budgeting calculations based upon NPV (net present value) criteria. The CAPM, which was developed in the context of financial securities markets, can be used to estimate this equity capital rate.

The CAPM divides a security’s risk into two components: unsystematic risk, which is company specific, and systematic risk, which is related to the movement of the stock market and wider economic factors. It is further argued that investors can, through an efficient diversification process (say, by holding a portfolio of twenty stocks or more), largely eliminate the company-specific, or unsystematic, component of risk. The only relevant risk faced by investors is systematic risk.

The equilibrium CAPM can be stated as:

\[ E(R) = R_f + \beta(E(R_m) - R_f), \]

where \( E(R) \) is the required rate;
\( R_f \) is the risk-free rate;
\( \beta \) is the estimate of systematic risk;
\( E(R_m) \) is the expected return on the market.
Table 1  
Results in Terms of NPV

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Point Estimate ($ millions)</th>
<th>Risk-Analysis Simulation ($ millions)</th>
<th>Probability (NPV &gt; 0)</th>
<th>NPV Such That 95% Probability of Exceeding That Value ($ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.12</td>
<td>3.53 0.84</td>
<td>0.99</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>0.85</td>
<td>0.74 0.45</td>
<td>0.94</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>2.90</td>
<td>0.94 1.37</td>
<td>0.88</td>
<td>-2.0</td>
</tr>
<tr>
<td>4</td>
<td>-1.38</td>
<td>-1.70 0.58</td>
<td>0</td>
<td>-3.0</td>
</tr>
</tbody>
</table>

Notes:  
1. Discount rate (i) in simulation calculations is assumed at 8%, net-of-tax, i.e., the riskless rate.  
2. Point estimate calculation is made using expected values for each input variable and appropriate net-of-tax risk-adjusted rate of return (using CAPM).  
3. Strategy 1 = superplant fast investment; strategy 2 = superplant slow investment; strategy 3 = small plant fast investment; strategy 4 = small plant slow investment.

To derive the cost of equity capital, forecasts using historical market data must first be generated for the right-hand-side variables ($\beta, \beta, E(R_m)$) in the CAPM and then substituted into the equilibrium equation. The cost of equity capital is equivalent to the required rate, $E(R)$.

The CAPM’s prescription for capital investment decision making can then be summarized in the following manner. It is assumed that the stated aim of management is to maximize the firm’s value as measured by shareholder wealth. In addition, assets are assumed to be priced in financial markets by discounting cash flows at a risk-adjusted rate; this rate reflects both the market’s risk premium and the volatility of the investment relative to the market. Therefore, for capital project appraisal, an individual project’s expected cash flows should be discounted by the appropriate risk-adjusted rate derived from the CAPM and from consideration of the debt/equity ratio (which might modify the weighted average cost of capital). Any project that increases the value of the firm (i.e., that has a positive NPV) when discounted at the risk-adjusted rate should merit acceptance if it confirms other criteria concerning its competitive value for the firm.

Results of the “First Pass” Risk Analysis.  
This section presents some results for the “first pass” risk analysis for the Egg’N Foam project. This single point estimate calculation is the NPV project appraisal using the risk-adjusted rate derived from the CAPM. The other calculations involve the direct use of risk simulation. The results for both the probabilistic risk analysis and the CAPM-based point estimate are summarized in Table 1. The cumulative density function (CDF) for the NPV for each of the strategies is presented in Figure 5.

According to the single point CAPM estimates in Table 1, strategy 4 could be eliminated since it has a negative NPV. The last two columns in the table present two possible additional choice criteria for each strategy: the probability that the NPV is positive, and the value of NPV such that there is a 95% probability of exceeding that value. Using these criteria, it would again appear that strategy 4 could be eliminated immediately.

In addition, using second-order principles of stochastic dominance, it would appear that strategy 1 dominates all other strategies since its CDF lies everywhere to the right of the CDFs for the other three strategies (see Figure 5). Therefore, strategy 1 appears to be the most viable alternative. However, as a contingency plan, strategy 2 appears to be the next best alternative, if in the first four years, the market growth projections are revised downward considerably.
Policy Dialogue

Following the initial risk analysis, the dialogue about strategy choice between the project and management teams at ABC focused on two main concerns. Although it was agreed that the sensitivity and risk analyses had aided the process of strategy evaluation by indicating key uncertain variables and by forecasting uncertain cash flows, it was felt that further discussion and review were necessary before choosing a strategy. Much controversy centered on the inadequacy of the processes of problem identification (including key assumptions), and the lack of specificity and clarity about ABC’s objectives. The strategic issues raised are outlined below.

Problem Identification. Typical critical comments from management included:

The team seems to have considered heavily technologically oriented strategies, i.e., concentration on plant size and speed of introduction for the product. Little emphasis was placed on interpreting the demand picture, which seems to suggest that marketing-related strategies have either not been considered or assumed away.

or

Why should the first step . . . be to construct a flow chart?

or

The team’s effectiveness might improve, if its composition were better balanced with the addition of some marketing personnel.

In general, it was felt that some problem assumptions and inputs should be examined and questioned more closely prior to a more effective “structuring” of the risk analysis model. It was agreed that both the initial listing of assumptions and the sensitivity
analysis in Figure 2 provided a valuable starting point for examining problem structure and the influence of problem assumptions. Some further observations were made about the assumptions. First, why did the ABC project team assume that ABC would produce its own sheets of foam when the option of purchasing from an outside source might be a worthwhile and cost-effective alternative? Second, what additional correlation effects (with their attendant measurement complications) should be included in the model in relation to price elasticity, demand, production rates, etc.? Third, why were market assumptions taken more or less as given, ignoring market-related strategies, thus reducing ABC's decision to an apparent choice of one of the four production strategies?

After considerable discussion, it was agreed that the greatest weakness concerned the marketing assumptions adopted in the model and the level of empirical or research effort available to support these assumptions. The following were some of the major areas in the treatment of marketing that were questioned:

— Market share will be 10 percent by 1978. (Should there be a spread of possible values?)

— No manufacturer other than Diamond National would enter the market before 1978.

— Paper carton manufacturers would not react violently to their share being cut from 50 percent to 5 percent in ten years. (Why would they not start a price war? Could they afford to do so?)

— Market forecasts are assumed to be correct. (Has any attempt been made to check their methodology and forecast accuracy?)

— Selling would be undertaken by the plastics marketing department. (It seemed that the transfer price would become an increasingly important motivating factor; this might indicate the need to establish a separate department for marketing Egg 'N Foam in the carton market.)

Pricing must be at a predetermined level for foam cartons. (Why not, for example, consider the adoption of penetration pricing policies to gain share in an aggressive manner?)

This last point deserves further elaboration. Penetration pricing policies involve setting a price that maximizes a firm's market share penetration, probably at the expense of current profits. The goal is the maximization of long-run profitability through the rapid attainment of market share. In this instance, Egg 'N Foam's strategy for market penetration would be to expand plant capacity as fast as possible (and certainly ahead of share) and to set the price lower than competitors in order to win share, achieve market growth, and discourage competition. In addition, ABC could take advantage of production and cost economies resulting from accumulated experience by continually lowering its price; such penetration pricing strategies are thus associated with exploitation of the experience curve strategy popularized by the Boston Consulting Group.

It was felt that two other financial management assumptions required further justification. First, working capital should not have been regarded as a single predetermined value. The amount required would depend upon the level of plant capacity, the accuracy of demand predictions (e.g., a stock pile-up might occur), the speed of payments by debtors, and many other (as yet unknown) factors. Second, the influence of inflation should not have been ignored. Inflation might, for example, affect foam more than pulp or vice versa, thus seriously changing the competitive balance within ABC. This could produce shortfalls in short-term cash flow, leading to an increase in short-term loans or in the time required to settle suppliers' accounts.
Specificity and Clarity of Objectives. Management felt that the project team was also uncertain about the criteria to be used in choosing among the available strategies. It was suggested, therefore, that attention be directed toward the criterion for strategy choice in relation to ABC's overall portfolio of investments, both current and projected. The main concerns were to relate single project risk to the firm's overall risk and to handle strategic issues. For example, it was necessary to consider whether the Egg'N Foam project would be too risky, not only in the sense of variability of returns, but also in terms of its effect on the firm's portfolio of projects, i.e., its long-term capital assets. Senior managers commented that the carton project might focus too great a proportion of the company's resources (financial, managerial, production, and marketing) on a single project to the detriment of other possible alternatives. This might weaken the firm's competitive edge in other strategic areas.

Conclusions of the Initial Policy Dialogue. It was agreed that certain tasks could be better performed by management than by the project team. It was also suggested that the project team, which was perhaps better balanced with marketing and financial expertise, should generate appropriate alternative strategies in line with management policy. Some form of strategic evaluation could be carried out later, using risk measures agreed upon jointly with management. Management's task should be to define guidelines for the range of strategies to be considered and to direct the project group in the decision-making task. A managerial dialogue process involving the consideration of other factors and attributes should ultimately determine the final strategy choice.

It should be emphasized that both groups stressed the importance of management's rule in the problem finding and formulation process. It was felt that the current strategy placed too much emphasis on production and R&D. It was also agreed that the range of strategies for consideration should focus on a close scan of the internal and external environment, as well as on a screen of potential competitive market and technological uncertainties.

As a result, the following recommendations were made concerning further strategy formulation and evaluation through the analytic process. First, greater attention should be paid to the influence of competition, competitive reaction, and marketing forces on the Egg'N Foam decision. In other words, strategies that combine marketing and production considerations should be developed. Management felt that the most sensible approach would be to develop a number of marketing scenarios (using a Delphi-type approach) and, if appropriate, to carry out a simulation of each scenario. For example, the following types of scenarios should be developed in association with each production alternative:

- Steady price;
- Failure of the market to grow meaningfully;
- Tough competitive reaction (e.g., price war initiated by Diamond National and others);
- A price war started by ABC to discourage other potential market entrants (i.e., an attempt to build up share quickly as required by an experience-curve type of strategy);
- Consumers preferring paper-based to plastic cartons.

Second, attention should be given in model development to working capital and cash flow management. For example, inflation effects and their impact on potential cash flow generation should be examined thoroughly. Third, output of the analytic process should be presented in terms of a series of performance measures (essentially policy indicator variables) over the project time horizon (fifteen years). This recommendation developed from the belief that the influence of
contingencies on a series of measures (such as cash flow and sales projections and NPV measures) would give valuable input to the process of strategy choice and perhaps would lead to the generation of additional strategy alternatives for policy dialogue. The performance measures suggested were:

— Total dollar sales,
— Cash flow profile,
— Gross profit as a percentage of sales,
— Net profit after taxes,
— Net profit as a return on investment,
— Net present value, and
— Further sensitivity analysis of results to key changes in input factors.

Subsequent Policy Dialogue. Management reviewed the subsequent output of the risk analysis, which showed that strategy 1 (superplant/fast investment) was still dominant, except under adverse marketing and financial scenarios when strategy 2 would be preferred. Interestingly, it was also determined (from the marketing scenarios) that ABC had a competitive strength with the plastic carton. As a result, if it adopted an even more aggressive capacity-building strategy, it might be able to obtain both the dominant market share position and the lowest relative cost position. This information provided a useful topic for discussion.

Management commented upon the value of the marketing and financial (e.g., cash flow) probabilistic forecasts provided by the “second pass” risk simulation. Quite apart from providing a better understanding of the influence of uncertain events on ABC’s business activities, it was felt that these forecasts gave an insight into the relationship between this particular project and the firm’s portfolio of activities.

Because the project’s NPV (for strategies 1 and 2) was positive when discounted at the required risk-adjusted rate (determined from capital asset pricing theories), the project merited acceptance in portfolio terms. This was reinforced by the strategic aspects of the risk simulation, which enabled management to judge the project’s viability under a range of alternative future scenarios. Indeed, managers commented that the confirmatory positive indications of the set of performance measures under the range of scenarios enabled them to better understand the project and assess its competitive potential.

While management generally favored project acceptance, a closer examination of ABC’s goals was desired. This was considered important to ensure that this project was compatible with the firm’s long-term growth plans and objectives. In order to develop this strategic thinking process, the firm’s portfolio was simulated, with the inclusion of either strategy 1 or strategy 2, over a five- to ten-year horizon in terms of profitability and cash flow objectives. It was hoped that this would highlight other business areas with potential for decline or growth, and would provide an assessment of cash flow and financial implications for the Egg’N Foam project.

This subsequent portfolio analysis showed sound long-term viability, and strengthened management’s view that some movement into the foam carton market would be a related business diversification providing the firm with a useful competitive edge. It was also felt that this project would be complementary in skills and growth potential to the firm’s recent diversifications into the poultry processing and broiler chicken manufacturing areas.

Risk Analysis as a Strategic Inquiry System

It is valuable to emphasize the link between risk analysis and strategic management. This can be conceptualized in terms of Churchman’s development of inquiry systems. Churchman’s inquiry systems are derived from interpretations of the writings of such philosophers as Leibnitz, Locke, Kant, Hegel, and Singer. Mitroff and Mason have also explained how these philosophical
stances can be used to provide frameworks for understanding problem formulation and solving processes, particularly in the policy field.  

Leibnitzian systems are characterized by the development of a single, near-optimal problem formulation, generally based upon some underlying theories and problem structures. This formulation of an analytic model of rational logical form is followed by data collection to support it and the generation of results, namely, deductive conclusions, which are consistent with the model. Lockean inquiry systems, however, have a much more empirical focus. Data are collected relevant to the decision problem, and the Lockean aim is to infer patterns from the data through inductive reasoning to support a single problem structure. Both Leibnitzian and Lockean systems are regarded as being suited to resolving well-structured problems.  

Kantian and Hegelian systems are more appropriate for resolving ill-structured policy and planning problems (such as the Egg’N Foam diversification issue), which arise in business applications. Kantian inquiry systems are characterized by the existence of multiple frameworks for viewing problems and by the existence of differing conceptual viewpoints. These viewpoints are based upon the differing assumption bases of the members of the decision-making group. Efforts are made to combine these views and to achieve consensus by presenting each set of underlying assumptions. Hegelian inquiry systems also involve multiple frameworks and viewpoints, but they require the introduction of conflict — challenging and questioning of assumptions — to achieve a sound problem formulation process. Through conflict, structured debate, and dialectical inquiry, a synthesis emerges.  

The initial risk analysis process shown in Figures 1 and 2 is a simple, somewhat naive form of a Leibnitzian inquiry system. In other words, a single “optimal” problem formulation is developed and data are collected to support this single “view of the world.” After the first pass risk analysis, the ensuing policy dialogue indicated, inter alia, that increased effort should be directed towards focused questioning of assumptions, scenarios, and product market concepts. Indeed, managers took the “devil’s advocate” position in their advocacy of extreme scenarios and alternative project assumptions. It should be noted that the use of risk analysis in the questioning and debate process indicates a significant change in the character of an inquiry system. The problem formulation system is now more complex and multidimensional, and is much closer to the inquiry systems described by Churchman, Kant, and Hegel. Several views about the problem are held, and it is believed that consensus and synthesis about problem formulation should be achieved through a process of group debate and dialogue. Further “passes” of risk analyses aid strategic dialogue by generating additional information for debate about the possible consequences of alternative assumptions, problem formulations, and future scenarios. This should lead to a continual review and updating of strategy options and to a resolution of conflicting viewpoints following structural debate.  

Conclusions and Strategic Implications  

The value of risk analysis in a facilities planning decision has been examined here in relation to a disguised planning situation called Egg’N Foam. Following Gluck’s approach, risk analysis is presented as Stage II/III of a sensible strategic thinking process. That is, risk analysis is a vehicle for forecast/uncertainty based planning, in which an understanding of future scenarios, cash flow projections, and synergies between marketing and production activities is developed. This framework enables managers to search more creatively in order to identify the menu of strategic options.  

The strategic risk analysis presented here differs from that presented by some other authors in the same area in terms of its
treatment of risk preference and criteria for strategy choice. Risk preference involves the decision maker's attitude towards risk, and is commonly handled via utility function assessment and certainty equivalence concepts. In this case, however, management felt uncomfortable with the utility concept, even though they regarded risk preference as a policy question. They preferred to treat risk preference through a number of "lenses" by examining the risk simulation output in mean/variance terms using "risk of ruin" criteria (i.e., probability of NPV > 0), and by looking at future cash flow profiles. In addition, they accepted that a project with a positive NPV, when discounted at an appropriate "risk-adjusted" rate, would increase the value of the firm in portfolio terms (thus, accepting the relevance of a market-determined risk preference function).

Management also felt that, for strategy choice, both the project and the firm's portfolio should be examined in terms of a number of performance measures (cash flow, NPV, sales) specified over the fifteen-year project time horizon. This criterion, specified in terms of a time stream of indicator measures (cash flow, etc.) rather than in terms of a single value (such as expected utility), is consistent with the work on preferences over time.

In terms of strategic implementation, this risk analysis approach was successful. Its value lies in encouraging policy dialogue among the management group about future uncertainty impacts, rather than in imposing a deductive solution derived from an analytic model. The continued questioning of assumptions and problem formulation is essential for the effective formulation and evaluation of alternative strategy positions. In this case, by such continued questioning and dialogue a meaningful consensus about strategy choice emerged. This consensus process, which involved "three passes" of a risk analysis process, could not have been achieved without the adaptive mechanisms and flexibility built into the process during the course of dialogue and successive risk analysis passes. Interestingly, the outcome was to follow strategy 2 (superplant/slow investment) with the proviso that should the market take off rapidly, a contingency plan for quickly adding further capacity would be immediately activated.

References


4. For the purpose of this study, the total market for egg cartons has been divided into five regions. Each represents a market that could be covered by the output
from one Egg'N Foam plant. The west coast was excluded from the analysis because entering this market was considered to be a separate decision not related to building plants in the other four regions. Egg'N Foam cartons cannot be shipped to the west coast as the freight costs are too high.

5 This is because caliper increase reduces the physical capacity of the plant.

6 The input data that were used for each strategy, as well as a more detailed description of the problem, can be obtained from the authors.

7 Superplant strategy assumes construction of two plants to serve the four regions, while the small plant strategy assumes construction of four plants.

8 See H. Raiffa, Decision Analysis (Reading, MA: Addison-Wesley, 1968).

9 See:

10 See:


16 See:
  R. O. Mason and I. I. Mitroff, Challenging Strategic Planning Assumptions (New York: John Wiley & Sons, 1981);


19 See Gluck, Kaufman, and Walleck (1980).

20 See:

21 See: