Strategic Assessment Model (SAM): A Multiple Criteria Decision Support System for Evaluation of Strategic Alternatives*

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ABSTRACT

The evaluation of strategic alternatives is a particularly difficult task. This difficulty is due to the complexities inherent in the evaluation process and the lack of structured information. The evaluation process must consider a multitude of relevant information from both the internal and external environments of the organization. Various analytical and normative models have helped decision makers utilize large volumes of information in strategic evaluation; however, most of these models have some limitations. We present a multiple criteria decision support system, called strategic assessment model (SAM), that addresses some of the limitations inherent in the existing models. SAM captures the decision maker's beliefs through a series of sequential, rational, and analytical processes. The environmental forces—decomposed into internal, task, general opportunities, and threats—are used along with the analytic hierarchy process (AHP), subjective probabilities, the entropy concept, and utility theory to enhance the decision maker's intuition in evaluating a set of strategic alternatives.

Subject Areas: Decision Analysis, Decision Processes, Decision Support Systems, and Strategy and Policy.

INTRODUCTION

Strategic management is the process of aligning the internal capabilities of an organization with the demands from its environment to achieve an effective allocation

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of corporate resources. Effective strategic management requires effective strategy formulation, evaluation of alternative strategies, and implementation of the selected strategy. Strategy formulation deals with "what to do" whereas strategy implementation deals with "how to get" the intended result. While both are integral parts of the same process, their nature and purposes are different. Because it is difficult to incorporate the entire strategic management process under one framework or model, the literature discusses different stages of the strategic management process separately. We focus on effective evaluation of strategic alternatives. The principal components of this evaluation process include: (1) generating alternative strategies, (2) identifying relevant factors along with their probabilities of occurrence, and (3) selecting the most attractive strategy based on an evaluation of the potential risks and returns associated with each alternative [52].

Many analytical and normative models have been developed to help a decision maker (DM) deal with the strategy evaluation process. Such models include strategic program evaluation (SPE) [18] [19] [26], quantitative strategic planning matrix (QSPM) [10] [11] [12], Electre II method (EII) [17], the McKinsey matrix [23], competitive strength assessment [55], the scenario-strategy matrix [37], and decision situation outcomes evaluation [39]. These techniques have made definite contributions to the strategy evaluation process, but they also have some limitations. For example, many of these techniques do not use comprehensive environmental data in the selection process. In addition, they do not consider the risk associated with a potential strategy. Finally, they use weights and subjective probabilities in the evaluation process but do not provide any systematic procedure to develop such weights and probabilities nor to verify their internal consistency.

We present a multiple criteria decision support system called Strategic Assessment Model (SAM) which overcomes some of the limitations of existing strategic evaluation models. SAM evaluates both environmental opportunities and threats, along with their probabilities of occurrence and their importance weights, to select a strategy based on the risk-adjusted strategic value. It also promotes comprehensive scanning of the environment by decomposing it into internal, task, and general environments as suggested by many researchers [9] [18] [40] [45]. Furthermore, SAM uses the Analytic Hierarchy Process (AHP) [41] [42] [44] for developing importance weights of the environmental factors, the entropy concept [60] for developing intrinsic weights of the environmental factors, and an exponential utility function [20] for calculating the risk-adjusted strategic value. These features make SAM a desirable tool for the evaluation of strategic alternatives.

Thus, SAM provides a greater level of analytical comprehensiveness than is provided by existing models. Initially, DMs may be overwhelmed by the number of different techniques and concepts that are integrated in SAM. However, they could be convinced to use SAM through patient assistance and training by experts, particularly when all the number crunching is performed by the computer. After all, DMs recognize that strategic decision making is complex and requires the use of several different analytical techniques to supplement managerial intuition, knowledge, and judgment.

CURRENT STRATEGY EVALUATION MODELS

An organization's strategy determines the degree of fit between the external environment and its internal structure and processes [25]. Many researchers have argued that such a match is best achieved by using a formal decision-making process [2] [7]. However, the lack of structure in the decision-making paradigm presents a major difficulty in developing a decision support system for the evaluation of strategic alternatives. This lack of structure is attributed to the novelty, complexity, and open-endedness of the strategic decision process [33]. Furthermore, the vast amount of information that must be considered for solving the inherently unstructured (or ill-structured) strategic problems creates a need for systematic and generic techniques for the evaluation of strategic alternatives [15] [28] [57].

Many analytical and normative models have been developed to aid DMs with the strategy evaluation process. Quantitative methods and approaches such as linear programming, game theory, Markov analysis, decision theory, and marginal analysis are among the methods recommended for strategic evaluation. These techniques, when properly used, can be extremely helpful [14]. However, such analytical techniques are more appropriate at the functional level where the parameters are relatively more specific and decision variables more quantifiable [8].

Other techniques for strategy evaluation include dialectical inquiry, devil's advocacy, and the consensus approach [49] [50] [51]. Although these techniques have a theoretical appeal, their application seems to be ad-hoc, and they do not present a structured framework for a systematic evaluation of different strategic alternatives. Schoemaker and Russo [47] describe four general approaches to decision making ranging from intuitive to highly analytical. These methods include intuitive judgments, rules and shortcuts, importance weighting, and value analysis. They argue that analytical methods such as importance weighting and value analysis are more complex but also more accurate than the intuitive approaches [47].

The literature reports three models for strategic evaluation that are similar to SAM. These are SPE [18] [19] [26], QSPM [10] [11] [12], and EII [17]. These models are easy to understand and apply, but they tend to oversimplify the problem description by ignoring critical details. For example, the importance of dividing the external environment into task and general environments is well-discussed in the literature [9] [18] [40] [45]. Yet, none of these techniques implement such a separate treatment of the task and general environments. Similarly, while risk is widely recognized as a very important criterion for strategy selection [27] [34], all of these techniques fail to incorporate a systematic treatment of risk and risk-averse management behavior. Furthermore, most of these techniques are variations of the decision matrix [24]. Although Hill et al. [24] did not incorporate the DM's utility function in the decision matrix, they emphasized the importance of utility consideration in the decision process. None of these methods use the DM's utility function in their model. In addition, these models use subjective probabilities and weights without defining a systematic procedure to develop them or to verify their internal consistency. Finally, all of these models utilize importance weighting. While they are useful for important and complex decisions such as strategic decisions, a more comprehensive assessment is needed. Value analysis approaches such as multi-attribute utility (MAU) improve importance weighting by considering the DM's utility [29]. These limitations of the existing models provided the motivation for developing SAM.

THE STRATEGIC ASSESSMENT MODEL

Background

The strategic decision-making environment is defined as the set of factors inside and outside the boundary of an organization that should be considered during strategic decision-making process. Environmental scanning is the process of seeking information about this environment. Many environmental scanning models treat the external environment as a single entity [35] [36] [38]. A major limitation of this approach is that task and general environments are not evaluated independently of one another.

We decompose the environment into internal, task, and general environments as suggested by many writers [9] [18] [40] [45]. These environments are defined as:

1. Internal Environment: The set of relevant factors that form the profile of the internal operations of the organization,
2. Task Environment: The set of relevant factors that have direct transactions with the organization. The influence between these factors and the organization is reciprocal, and
3. General Environment: The set of relevant factors that can exert considerable influence on the organization. The organization, however, has little or no impact on such factors.

A major advantage of decomposing the environment is that the relative weights of different environments can be specified independently of the relative weights of the factors within the environment. SAM uses both environmental opportunities and threats along with subjective probabilities and weights to provide additional information about each alternative. Opportunities and threats are positive and negative factors within the internal, task, and general environments.

The Procedure

SAM uses an eight-step procedure to systematically evaluate potential strategies by calculating the expected utility associated with each alternative. The risk-adjusted strategic value of an alternative is directly related to the expected utility of the alternative through the utility function. Below are the eight steps used in SAM followed by a description of each step.

1. Generate strategic alternatives.
2. Identify the relevant opportunities and threats and group them into internal, task, and general sets of environmental factors.
3. Define environmental weights.
4. Calculate the initial weights associated with the opportunities and threats.
5. Develop subjective probabilities for each alternative.
6. Calculate the overall importance weight for the opportunities and threats.
7. Measure the DM's risk-aversion constant for the opportunities and threats.
8. Calculate the risk-adjusted strategic value for each alternative.

1. *Generate strategic alternatives.* Alternatives are the set of potential means by which the stated objectives may be attained. There must be at least two mutually

exclusive alternatives in the set to permit a choice to be made [60]. Alternatives can be generated using various brainstorming and intuitive methods.

2. *Identify the relevant opportunities and threats and group them into internal, task, and general sets of environmental factors.* We use "scanning" and "interpretation" to identify relevant opportunities and threats and group them into environmental sets. Scanning involves searching the environment to identify the information that is pertinent to the organization. Interpretation is the process of comprehending the information and deciding which factors to include in each environmental set [47] [54]. The set of opportunities and threats included in SAM is not necessarily the entire set of opportunities and threats that could be realized by the firm but consists only of those that can be "exploited" by the strategic alternatives. In other words, an opportunity such as a 2 percent decrease in energy costs would not be included in the model if it was not relevant to the strategic problem under consideration. The internal environment consists of opportunities and threats within functional areas of a firm such as organization, personnel, and marketing. The task environment includes opportunities and threats associated with competitors, customers, regulatory agencies, labor market, creditors, and suppliers which have direct transactions with the organization. The general environment includes mainly uncontrollable international, economic, political, legal, social, cultural, and demographic factors. Aguilar [1] presents a detailed discussion of environmental factors to be considered during the strategic decision-making process.

3. *Define environmental weights.* Several approaches such as point allocation, paired comparisons, trade-off analysis, and regression estimates could be used to specify the relative importance of the internal, task, and general environments [29]. Paired comparisons were used because it captures the ratio of importance for every conceivable pair of environments, and it is found to be trustworthy and easy to use [29]. SAM utilizes AHP, developed by Saaty [41] [42] [44], to estimate environmental weights for opportunities (W_{u_i}) and threats (W_{t_i}) factors. The advantage of AHP is its capability to elicit judgments and scale them uniquely using a valid procedure that measures the consistency of these scale values [43]. AHP is a widely used technique, and an earlier survey listed well over 200 applications of AHP in the literature [59]. Some researchers have questioned the theoretical basis underlying AHP. However, Harker and Vargas [21] show that AHP does have an axiomatic foundation, the cardinal measurement of preferences is fully represented by the eigenvector method, and the principles of hierarchical composition and rank reversal are valid. While several variations of AHP have been introduced [3] [32] [48] [58], the original AHP developed by Saaty [42] is still being widely used. In addition, the software package Expert Choice [16] utilized in SAM is based on the original methodology.

4. *Calculate the initial weights associated with the opportunities and threats.* The initial weights associated with each opportunity ($W_{u_{ij}}$) and threat ($W_{t_{ij}}$) are calculated next. AHP is used to simplify the estimation process by confining the estimates to pairwise comparisons of factors within each environment. The measure of inconsistency provided by AHP allows for the examination of inconsistent priorities. In step 6, this initial weight is adjusted to capture the amount of intrinsic information transmitted by each factor.

5. *Develop subjective probabilities for each alternative.* We estimate the probability of occurrence of each opportunity ($p^m_{u_{ij}}$) and threat ($p^m_{t_{ij}}$) for each alternative. Subjective probabilities are commonly used in strategic decision making since they require no historical data (observation of regularly occurring events by their long-run frequencies) [13] [46] [47] [56] [57]. Subjective probabilities can be measured by asking a DM for the odds on an event. Various techniques exist to improve subjective probability judgments. One approach uses probabilistic phrases such as impossible, possible, likely, and certain to elicit the required information, and then converts these non-numeric estimates into numeric probabilities [5] [6]. In another simple approach known as reasoning, the DM is asked to list the reasons why he/she believes an event may turn out one way versus another [30]. A related approach is scenario construction which examines reasons or events in combination. By constructing detailed scenarios, a DM is more likely to stretch his/her confidence ranges [46]. A more sophisticated approach is cross-impact analysis. Cross-impact analysis is recommended for calibrating the initial subjective probabilities if the DM believes that there is a high degree of interaction among the environmental factors. Once the probability of occurrence for each factor is estimated, the DM develops conditional probabilities to capture the interactions among these factors. These conditional probabilities are estimated in response to the question, "If one factor occurs, what is the new probability of the second factor?" Stover and Gordon [53] present a complete and step-by-step treatment of cross-impact analysis.

It is assumed that the subjective probability of realizing a situation is binomial. The properties of binomial probabilities are used for calculating the risk-adjusted strategic value associated with each potential alternative. Binomial probabilities are commonly used in strategic decision making because the DM can simplify the problem by analyzing possible outcomes as either occurring or not occurring. For example, Schoemaker [46, p. 206] assigns binomial probabilities to factors such as "U.S. economic GNP growth of at least 4% per annum by the end of 1990" or "Short-term interest rates exceeding 13% in the U.S.A. sometime during the next 5 years." Vickers [56, p. 798] also assigns binomial probabilities to similar factors such as, "A speed limit is imposed upon the German four lane highways" and "Japanese car manufacturers gain at least 30% of the European market share" in order to examine the future of European automobile industry.

In SAM, AHP is not used for this step for two reasons. First, we are interested in capturing the probability of occurrence rather than relative weights of the factors. Second, we wish to avoid the effort required to complete all pairwise comparisons in large hierarchies [32] [58].

6. *Calculate the overall importance weight for the opportunities and threats.* SAM views decision making as an information processing task and a large amount of information about the strategic alternatives is processed through their opportunities and threats. Given the fact that opportunities and threats are information sources, the more information is revealed by the *j*th factor in the *i*th environment, the more relevant is the factor in the decision analysis. Zeleny [60] argues that this intrinsic information must be used in parallel with the initial weight assigned to various factors by the DM. In other words, the overall importance weight of an opportunity, $\hat{F}_{u_{ij}}$, is directly related to the intrinsic weight, $F_{u_{ij}}$, reflecting average

intrinsic information developed by a set of alternatives, and the subjective weight, $W_{u_{ij}}$, reflecting the subjective assessment of its importance rendered by the DM. The probabilities of occurrence are used to measure this average intrinsic information. The more different the probabilities of a factor are for a set of alternatives, the larger is the contrast intensity of the factor, and the greater is the amount of information transmitted by that factor. In this section, all formulas necessary for calculating the overall importance weight of opportunities are presented. However, this procedure is identical for the calculation of the overall importance weight of threats.

Assume that vector $p_{u_{ij}}=(p^1_{u_{ij}}, \ldots, p^q_{u_{ij}})$ characterizes the set P in terms of the jth factor in the ith environment and define:

$$P_{ij} = \sum_{m=1}^{q} p^m_{u_{ij}} \qquad \text{for } i = 1, \ldots, 3 \text{ and } j = 1, \ldots, N_{u_i}. \tag{1}$$

Then, the entropy measure of the jth opportunity factor in the ith environment is:

$$e(p_{u_{ij}}) = -K \sum_{m=1}^{q} \frac{p^m_{u_{ij}}}{P_{ij}} \ln \frac{p^m_{u_{ij}}}{P_{ij}}, \tag{2}$$

where $K>0$, ln is the natural logarithm, $0 \le p^m_{u_{ij}} \le 1$, and $e(p_{u_{ij}}) \ge 0$. When all $p^m_{u_{ij}}$ are equal for a given i and j, then $p^m_{u_{ij}}/P_{ij}=1/q$, and $e(p_{u_{ij}})$ assumes its maximum value, which is $e_{\max}=\ln q$. By setting $K=1/e_{\max}$, we achieve $0 \le e(p_{u_{ij}}) \le 1$. This normalization is necessary for meaningful comparisons. In addition, the total entropy is defined as:

$$E = \sum_{j=1}^{N_{u_i}} e(p_{u_{ij}}). \tag{3}$$

The smaller $e(p_{u_{ij}})$ is, the more information is transmitted by the jth opportunity factor in the ith environment and the larger $e(p_{u_{ij}})$, the less information is transmitted. When $e(p_{u_{ij}})=e_{\max}=\ln q$, the jth opportunity factor in the ith environment is not transmitting any useful information. Next, the intrinsic weight is calculated as:

$$F_{u_{ij}} = \frac{1}{N_{u_i} - E} [1 - e(p_{u_{ij}})]. \tag{4}$$

Since $F_{u_{ij}}$ is inversely related to $e(p_{u_{ij}})$, $1-e(p_{u_{ij}})$ is used instead of $e(p_{u_{ij}})$ and normalized to make sure $0 \le F_{u_{ij}} \le 1$ and

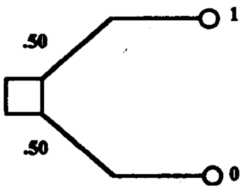
$$\sum_{j=1}^{N_{u_i}} F_{u_{ij}} = 1.$$

The more different the subjective probabilities $p^m_{u_{ij}}$ are, the larger $F_{u_{ij}}$, and the more important the jth opportunity factor in the ith environment is. When all the subjective probabilities $p^m_{u_{ij}}$ are equal, then $F_{u_{ij}}$=0. In order to calculate the overall importance weight of the jth opportunity factor in the ith environment, $\hat{F}_{u_{ij}}$, the intrinsic weight, $F_{u_{ij}}$, is multiplied by the subjective weight, $w_{u_{ij}}$, and then the product is normalized:

$$\hat{F}_{u_{ij}} = \frac{F_{u_{ij}} \cdot w_{u_{ij}}}{\sum_{j=1}^{N_{u_i}} F_{u_{ij}} \cdot w_{u_{ij}}}. \tag{5}$$

This procedure is not employed to adjust the weight assigned to each environment, because the average intrinsic information transmitted to the DM through the ith environment cannot be measured.

7. *Measure the DM's risk-aversion constant for the opportunities and threats.* Assuming the DM is averse to risk and his or her utility function is exponential, the DM's risk-aversion constant (r) is calculated for each opportunity ($r_{u_{ij}}$) and threat ($r_{t_{ij}}$). Certainty Equivalence (CE), Probability Equivalence (PE), Gain Equivalence (GE), and Loss Equivalence (LE) are among the various techniques that could be used to measure the risk-aversion constant [22]. We prefer using CE as it is suggested by Bodily [4]. According to CE, the DM is offered the following gamble:



where 1 represents the occurrence and 0 represents the non-occurrence of an opportunity or threat. Given the expected value of .50(1)+.50(0)=.50 for the above lottery, the DM is asked to provide his or her CE between 0 and .50. CE=0 represents complete risk-aversion ($r=\infty$) while CE=.50 represents complete risk-neutrality (r=0). Assuming CE is equal to p and the DM's utility function is given by $u(p)=1/r(1-e^{-rp})$, the value of r that satisfies the given CE using $e^{-rp}-.5e^{-r}=.5$ can be found. This equation is derived by setting the utility of the CE, $u(p)=1/r(1-e^{-rp})$, equal to the expected utility of the lottery, *Expected Utility*=.5u(1)+.5u(0). It is always recommended to use more than one kind of question or approach to assure that the risk-aversion constant represents the feelings of the DM.

8. *Calculate the risk-adjusted strategic value for each alternative.* Assuming an exponential utility function for the DM, SAM was developed using Gupta and Cozzolino's [20] formula for the risk-adjusted value of a binomial distribution. The

details of the model are presented in the next section. An exponential utility function was used because it is the simplest model of risk-aversion, and the risk-adjusted value is not a function of the DM's wealth [20]. The risk-adjusted strategic value of an alternative (V^m) is a measure of the attractiveness of the alternative calculated by adding the risk-adjusted opportunity value of the alternative (U^m) to the risk-adjusted threat value (T^m). It should be noted that the positive opportunities and negative threats result in $1 \geq U^m \geq 0$, $0 \geq T^m \geq -1$, and $V^m = U^m + T^m$. These two values are in turn calculated by summing the multiplication of the relative weight of each type of environment to the relative weight of each factor within that environment and the risk-adjusted value associated with the probability of occurrence of that factor for the selected alternative. Given a DM's risk-aversion constant, the higher the risk-adjusted strategic value, the more attractive an alternative will be.

The Algebraic Model

To formulate an algebraic model of SAM, let us assume:

V^m = Total weighted risk-adjusted strategic value of the *m*th strategic alternative, (m=1, 2, ..., q),

U^m = Total weighted risk-adjusted opportunity value of the *m*th strategic alternative, (m=1, 2, ..., q),

T^m = Total weighted risk-adjusted threat value of the *m*th strategic alternative, (m=1, 2, ..., q),

W_{u_i} = The *i*th environment weight for opportunities, (i=1, 2, and 3),

W_{t_i} = The *i*th environment weight for threats, (i=1, 2, and 3),

$\hat{F}_{u_{ij}}$ = The overall importance weight for the *j*th opportunity factor in the *i*th environment, (j=1, 2, ..., N_{u_i}; and i=1, 2, and 3),

$\hat{F}_{t_{ij}}$ = The overall importance weight for the *j*th threat factor in the *i*th environment, (j=1, 2, ..., N_{t_i}; and i=1, 2, and 3),

$p^m_{u_{ij}}$ = The *m*th probability of occurrence of the *j*th opportunity factor in the *i*th environment, (m=1, 2, ..., q; j=1, 2, ..., N_{u_i}; and i=1, 2, and 3),

$p^m_{t_{ij}}$ = The *m*th probability of occurrence of the *j*th threat factor in the *i*th environment, (m=1, 2, ..., q; j=1, 2, ..., N_{t_i}; and i=1, 2, and 3),

N_{u_i} = Number of opportunity factors in the *i*th environment, (i=1, 2, and 3), and

N_{t_i} = Number of threat factors in the *i*th environment, (i=1, 2, and 3).

Assuming that i=1 through 3 represent the internal, task, and general environments, respectively, the risk-adjusted strategic value for the *m*th strategic alternative is:

$$V^m = U^m + T^m, \tag{6}$$

where

$$U^m = \sum_{i=1}^{3} W_{u_i} \left(\sum_{j=1}^{N_{u_i}} \hat{F}_{u_{ij}} \left[-\frac{1}{r_{u_{ij}}} \ln\left(1 - p^m_{u_{ij}} + p^m_{u_{ij}} e^{-r_{u_{ij}}}\right) \right] \right), \tag{7}$$

$$T^m = \sum_{i=1}^{3} W_{t_i} \left(\sum_{j=1}^{N_{t_i}} \hat{F}_{t_{ij}} \left[-\frac{1}{r_{t_{ij}}} \ln(1 - p_{t_{ij}}^m + p_{t_{ij}}^m e^{r_{t_{ij}}}) \right] \right), \tag{8}$$

and

$r_{u_{ij}}$ = the DM's risk-aversion constant for the *j*th opportunity factor in the *i*th environment, and

$r_{t_{ij}}$ = the DM's risk-aversion constant for the *j*th threat factor in the *i*th environment.

The DM's risk-aversion constant (r) is assumed to be greater than zero, representing aversion toward risk. SAM does not consider r=0, which represents risk neutrality, or r<0, which represents preference toward risk, a behavior which is not evident in the world of business [20]. In addition:

$$\sum_{i=1}^{3} W_{u_i} = 1, \tag{9}$$

$$\sum_{i=1}^{3} W_{t_i} = 1, \tag{10}$$

$$\sum_{j=1}^{N_{u_i}} \hat{F}_{u_{ij}} = 1, \tag{11}$$

$$\sum_{j=1}^{N_{t_i}} \hat{F}_{t_{ij}} = 1, \tag{12}$$

$$0 \le p_{u_{ij}}^m \le 1, \tag{13}$$

$$0 \le p_{t_{ij}}^m \le 1. \tag{14}$$

A PRACTICAL APPLICATION

This example presents, in condensed form, a real-life problem. The name of the company has been changed to protect its identity. The study is centered on The City Hospital (TCH), a leading health care provider associated with the medical school of a university. The facility is involved in research and education in various facets of the health care profession. Like many other hospitals, TCH is faced with several challenges, not the least of which are financial in nature. The state legislature has eliminated much of its funding to the university resulting in a $10 million operating deficit for the hospital. Furthermore, the business community is seeking a reduction in health care costs. TCH expects that new regulations from government and private sectors will require care for an increased number of patients and provide for less funding. It also anticipates major changes in the funding for education and research, an increased emphasis on managed care competition, additional support for applied research, a global budget for health care, and taxing of health care benefits. All of these factors will have a significant impact on TCH's operating budget and future success.

Given the current situation, TCH must reduce its operating budget by 4.5 percent or $20 million and maintain its position of leadership in the health care industry. TCH management views this challenge as an opportunity to restructure costs by streamlining and improving operations, and exploring new strategies for generating revenues. The selected strategy must preserve the present high quality services. In order to achieve this objective, the DM identified the following five alternative strategies (step 1). Because of budgetary constraints, these alternatives were considered mutually exclusive.

1. *Alternative A (Implement a New Electronic Billing System)*: Replace the present antiquated claim submission system. New hardware and software costs are expected to be minimal, and employee training will be conducted by information systems personnel. This alternative is expected to reduce the work force, increase claim processing accuracy, minimize the float of accounts receivable, and automatically create all necessary reports required by government regulations.

2. *Alternative B (Centralize the Decentralized Business Offices)*: Currently, each of the hospital's medical services has a decentralized business office. The centralization of these offices should reduce direct costs, increase economies of scale, and produce more accurate information. TCH's cash flow should increase as delays in payments and billing errors are reduced.

3. *Alternative C (Create a Medical Observation Unit)*: Many patients do not require hospital admission for emergency care; however, their symptoms may need to be monitored. The DM believes that TCH can benefit by creating a medical observation unit for such patients, since insurers are less likely to deny claims for stays in observation units than hospitalization for observation.

4. *Alternative D (Implement Case Management Program)*: Under this program, patient care and services are integrated and provided by teams of professionals. Such reorganization should reduce staff turnover, employee error, average length of patient stay, and waiting time for outpatient registration. In addition, the reorganization should increase physician, staff, and patient satisfaction.

5. *Alternative E (Form a Managed Care Organization)*: Managed care is the type of care provided by Health Maintenance Organizations (HMO's) and Prospective Payment Organizations (PPO's). This program limits the patient's choice of physicians, but provides a more organized and cost efficient system of care. A managed care organization will produce new sources of hospital revenues and ultimately lower the cost of care through reduced lengths of stay and more cost efficient medical decision making.

The next step (step 2) is the identification of the relevant opportunities and threats. After a careful analysis of the situation, the DM identified 13 opportunities and 12 threats associated with these operational challenges. Given the environmental definitions described earlier, the DM categorized these factors into internal, task, and general environments. For example, a positive factor such as "a minimum of 5 percent increase in productivity" was considered to be an opportunity in the internal environment, while a negative factor such as "reduction of inpatient services by 8 percent" was considered to be a threat in the task environment. A list and brief description of the opportunities are presented in Table 1, and the threats are presented in Table 2.

The DM then defined the environment-related weights through a series of pairwise comparisons required by AHP (step 3). Using Expert Choice software, the DM provided the pairwise comparisons presented in Table 3. Expert Choice synthesized these judgments and provided the DM with the relative weights and the inconsistency ratios (also presented in Table 3). The DM was asked to re-evaluate his judgments if the inconsistency ratio was greater than 10 percent. It is clear that the opportunities in the internal environment with a weight of .637 outweigh other opportunities and that the threats in the task environment were most important (.659).

Next (step 4), Expert Choice was used by the DM to evaluate all sets of environmental factors. For example, 10 pairwise comparisons were made between the internal opportunities (ROS, IIP, ESL, COM, and ICS) (Table 4). Next, Expert Choice used these judgments and provided the DM with the relative weights associated with each environmental factor. Again, when the inconsistency ratio was greater than 10 percent, the DM is asked to re-evaluate his judgments in the pairwise comparison matrix. One pairwise comparison matrix is needed for each set of opportunities and threats in the internal, task, and general environments. Therefore, the process of entering the judgments was repeated by the DM six times. All mathematical manipulations were performed by Expert Choice. The sorted details of the pairwise comparisons and weights for the opportunities are given in Table 4 and the same for the threats in Table 5.

Next, the DM estimated the probability of occurrence for each opportunity and threat under each potential alternative (step 5). Only a small part of this step for 'Alternative A' is presented for illustrative purposes. In analyzing whether or not to implement a new electronic billing system in Alternative A, it was believed that National Electronic Information Corporation (NEIC), a nationwide electronic claims collection and distribution system would be a valuable asset to the hospital. Start up costs for the equipment were deemed minimal.

The NEIC system would necessitate a change in the way employees do business. A reduction of staff (ROS) by 2 percent was believed to be 90 percent likely to occur. NEIC tremendously reduces the number of paper bound steps between the health care provider's submission of claims and its payment. As with most operational changes, there is often some resistance on the part of individual employees. Although employee and physician resistance to change (RTC) was 40 percent likely to occur, it was expected that this resistance would be short-lived. As employees familiarize themselves with the equipment, they would realize that their workload would decrease by about 30 percent. Furthermore, the DM believed that it was 70 percent likely that this alternative would increase productivity (IIP) by a minimum of 5 percent. In addition, this system was 60 percent likely to increase employee skill level (ESL) as individuals master this new technology. Finally, it was expected that installing this new claim processing system is 40 percent likely to improve communications (COM) and 80 percent likely to improve customer service (ICS).

This analysis was continued until all opportunities and threats were examined. Similar analyses for the other alternatives were performed. A summarized listing of

Table 1: Environmental opportunities.

Internal Enviroment

ROS (Reduction of staff by 2 percent): Wages and benefits represent 60 percent of expenses. Therefore, a 2 percent decrease in staffing will reduce the operating budget by $486,000.

IIP (A minimum of 5 percent increase in productivity): The hospital productivity may be increased by streamlining (e.g., specifying procedures) and eliminating duplication.

ESL (An above average increase in employee skill level): Skill level could be increased by combining tasks, forming identifiable work units, establishing client relationships, and vertical job loading.

COM (Improving communications): Successful implementation of management update meetings should improve internal communication, enhancing relationships between employees, management, and physicians.

ICS (Improving customer service): An earlier study concerning patient waiting times, courtesy of staff, comfortableness of facility, and overall employee awareness has served to identify deficiencies in customer service. Change in these areas may improve services and put the hospital in the forefront.

Task Environment

HQC (Providing high quality patient care): Quality of care provided by non-medical services influences TCH's business relationship. Management believes that it is necessary to increase the quality of patient care to an above industry average level.

PHR (Improving hospital and physician relationships): A quality management program may improve physician/hospital relationships and facilitate health care reform.

IMS (Increasing market share by 8 percent): TCH can increase its business by 8 percent through cost cutting, and new and enhanced programs. Being a visionary while reducing cost will help TCH.

MCB (Increasing managed care business by 10 percent): TCH may begin to negotiate with insurance companies to increase managed care business from 4 percent to 10 percent within the next two years.

IOS (Increasing outpatient services by 6.5 percent): Economic forces will continue to push patient care to the outpatient setting. TCH may increase outpatient service by 6.5 percent within the next two years.

General Environment

RGC (Responding to new governmental changes): Short and long term strategies formulated to safeguard TCH can take advantage of new government regulations.

GFA (Increasing government financial assistance to uninsured persons): The uninsured population will eventually become insured which will increase TCH's net operating income. Currently about 15 percent of the patients serviced are not insured.

AGL (Availing special government loans): Some of the proposed changes may be supported through funding from various government loans.

Table 2: Environmental threats.

Internal Environment	
RTC	(Employee/physician resistance to change): TCH employees/physicians are used to a stable environment and are likely to resist changes which can stall proposed improvements.
IEX	(Increase in educational expenses): Implementation of new programs require training and education of employees. An above average increase in educational expenses will have a negative impact on the hospital's budget.
RDE	(Placement of displaced employees within the hospital): The probability of rehiring a laid-off employee is minimal. This may be detrimental to employee morale and performance.
LAS	(Lack of available office space): Some changes will require trading smaller offices for larger ones. This is a problem because office space is a scarce resource.
Task Environment	
NPH	(Negative perception of the hospital): Implementation of certain programs may require lay-off and other cost cutting measures which could draw media attention, creating a negative image of TCH.
RIS	(Reduction of inpatient services by 8 percent): The push toward more outpatient services should reduce inpatient services, which in turn could reduce TCH's revenue.
SAD	(Denial of short-stay admissions): Payment for short hospital stays are being denied by third party payers. Such insurance regulations will have a negative impact on the budget.
CSU	(Clerical staff joining the union): Staff reductions, threat of anticipated changes, etc., may induce non-union clerical staff to join the union who will resist such changes.
ILC	(Above average increase in litigation cases): Present political climate indicates a potential increase in antitrust suits. Therefore, cost control efforts might end up in court.
General Environment	
TMC	(Threat of managed competition): Managed competition could impact the quality of care. Third parties will have more to say about patient care than doctors.
RIP	(Lower reimbursement from insurance): Lower reimbursement poses a threat, because a decrease in payments and an increase in discounts will reduce the net operating income.
RGR	(Lower reimbursement due to governmental regulations): Lower reimbursement due to new governmental regulations poses a similar threat to the net operating income.

occurrence probabilities associated with all opportunities and threats for all alternatives is presented in Table 6. These probabilities and weights were all stored in a spreadsheet.

Next (step 6), the overall importance weights for the opportunities and threats were calculated given the initial weights and the intrinsic information provided by the subjective probabilities. This step was totally automated, and the DM was provided with only a revised set of importance weights. A spreadsheet macro was used to perform all necessary mathematical calculations. The opportunities in the

Table 3: Environmental pairwise comparison matrices.

	Internal	Task	General	Relative Weight
Opportunities (Inconsistency Ratio = .037)				
Internal	1	3	5	.637
Task	1/3	1	3	.258
General	1/5	1/3	1	.105
Threats (Inconsistency Ratio = .031)				
Internal	1	7	4	.079
Task	1/7	1	3	.659
General	1/4	1/3	1	.262

Table 4: Pairwise comparison matrices (opportunities).

Internal Environment (Inconsistency Ratio = .038)

	ROS	IIP	ESL	COM	ICS	Relative Weight
ROS	1	3	4	5	7	.484
IIP	1/3	1	3	4	5	.262
ESL	1/4	1/3	1	2	4	.131
COM	1/5	1/4	1/2	1	2	.077
ICS	1/7	1/5	1/4	1/2	1	.046

Task Environment (Inconsistency Ratio = .027)

	HQC	PHR	IMS	MCB	IOS	Relative Weight
HQC	1	2	4	6	8	.460
PHR	1/2	1	3	4	6	.288
IMS	1/4	1/3	1	3	4	.142
MCB	1/6	1/4	1/3	1	2	.068
IOS	1/8	1/6	1/4	1/2	1	.042

General Environment (Inconsistency Ratio = .077)

	RGC	GFA	AGL	Relative Weight
RGC	1	7	6	.760
GFA	1/7	1	2	.144
AGL	1/6	1/2	1	.096

Table 5: Pairwise comparison matrices (threats).

Internal Environment (Inconsistency Ratio = .045)

	RTC	IEX	RDE	LAS	Relative Weight
RTC	1	3	5	7	.568
IEX	1/3	1	3	4	.252
RDE	1/4	1/3	1	2	.121
LAS	1/5	1/4	1/2	1	.059

Task Environment (Inconsistency Ratio = .020)

	NPH	RIS	SAD	CSU	ILC	Relative Weight
NPH	1	2	3	5	7	.429
RIS	1/2	1	3	4	6	.303
SAD	1/3	1/3	1	2	4	.143
CSU	1/5	1/3	1/2	1	2	.079
ILC	1/7	1/6	1/4	1/2	1	.046

General Environment (Inconsistency Ratio = .037)

	TMC	RIP	RGR	Relative Weight
TMC	1	3	5	.637
RIP	1/3	1	3	.258
RGR	1/5	1/3	1	.105

internal environment were used to show how the revised weights were calculated in the Microsoft Excel spreadsheet. Consider m=1, 2, 3, 4, and 5 (alternatives A, B, C, D, and E); j=1, 2, 3, 4, and 5 (opportunity factors ROS, IIP, ESL, COM, and ICS); i=1 (internal environment); and $p_{u_{ij}}^{m}$ representing the probability of occurrence of five alternatives on five opportunity factors in the internal environment. First the entropy measure of the jth opportunity factor, $e(p_{u_{ij}})$, was calculated. Table 7 contains the information necessary to calculate $e(p_{u_{ij}})$.

$$\text{Given } e_{\max} = \ln 5 = 1.6094, \text{ by setting } K = 1/e_{\max} = .6213, \quad \text{for } j = 1:$$

$$e(p_{u_{11}}) = -(.6123)[.281(\ln .281) + .281(\ln .281) + .031(\ln .031) + .188(\ln .188) + .219(\ln .219)].$$

In summary,

$$e(p_{u_{11}}) = .912,\ e(p_{u_{12}}) = .910,\ e(p_{u_{13}}) = .863,\ e(p_{u_{14}}) = .969,\ e(p_{u_{15}}) = .952,$$

Table 6: Summarized comparison between strategic alternatives.

	Environmental Weight	Overall Weight	Risk Aversion	Alternatives A	B	C	D	E
Opportunities								
ROS		.480	.8000	.90	.90	.10	.60	.70
IIP		.265	.7000	.70	.80	.10	.70	.40
ESL	.637	.203	.0040	.60	.10	.40	.90	.20
COM		.027	.0010	.40	.80	.50	.80	.40
ICS		.025	.0900	.80	.80	.30	.90	.40
HQC		.447	.6000	.80	.90	.10	.70	.80
PHR		.193	.0700	.40	.20	.70	.80	.70
IMS	.258	.109	.9000	.20	.30	.60	.70	.30
MCB		.154	.8000	.20	.10	.10	.80	.50
IOS		.097	.0600	.20	.10	.10	.60	.80
RGC		.127	.0020	.90	.70	.90	.70	.90
GFA	.105	.415	.0500	.70	.70	.10	.80	.70
AGL		.458	.0080	.20	.10	.60	.80	.80
Risk-adjusted Opportunity Value				.635	.591	.206	.658	.522
Threats								
RTC		.114	.0001	.40	.60	.40	.70	.50
IEX	.079	.445	.0030	.20	.10	.60	.80	.90
RDE		.316	.0070	.80	.90	.10	.30	.10
LAS		.125	.0800	.10	.90	.80	.20	.30
NPH		.367	.8000	.10	.30	.40	.40	.10
RIS		.480	.0900	.20	.40	.90	.20	.10
SAD	.659	.039	.1000	.10	.10	.10	.20	.10
CSU		.064	.7000	.20	.30	.10	.40	.10
ILC		.050	.8000	.10	.10	.10	.30	.40
TMC		.729	.0400	.10	.10	.30	.20	.80
RIP	.262	.129	.6000	.20	.10	.10	.30	.40
RGR		.142	.5000	.10	.10	.10	.40	.80
Risk-adjusted Threat Value				-.183	-.317	-.522	-.337	-.335
Risk-adjusted Strategic Value				.452	.274	-.316	.321	.187

and E, the sum of all $e(p_{u_{ij}})$, was 4.606. Substituting in the formula for $F_{u_{ij}}$, the intrinsic weights worked out to be

$$F_{u_{11}} = .223,\ F_{u_{12}} = .228,\ F_{u_{13}} = .349,\ F_{u_{14}} = .078,\text{ and } F_{u_{15}} = .123.$$

The initial weights ($w_{u_{ij}}$) had already been estimated by the DM as:

$$w_{u_{11}} = .484,\ w_{u_{12}} = .262,\ w_{u_{13}} = .131,\ w_{u_{14}} = .077,\text{ and } w_{u_{15}} = .046.$$

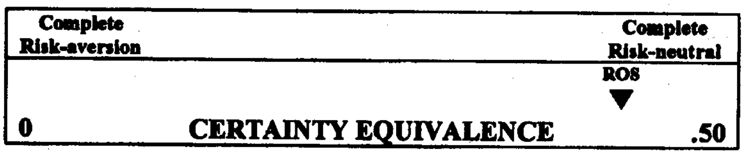
Table 7: Information necessary for calculating $e(p_{u_{ij}})$.

	$p^m_{u_{ij}}$						$p^m_{u_{ij}}/p_{ij}$				
Factor	A	B	C	D	E	P_{ij}	A	B	C	D	E
ROS	.90	.90	.10	.60	.70	3.20	.281	.281	.031	.188	.219
IIP	.70	.80	.10	.70	.40	2.70	.259	.296	.037	.259	.148
ESL	.60	.10	.40	.90	.20	2.20	.273	.045	.182	.409	.091
COM	.40	.80	.50	.80	.40	2.90	.138	.276	.172	.276	.138
ICS	.80	.80	.30	.90	.40	3.20	.250	.250	.094	.281	.125

Comparing $w_{u_{ij}}$ and $F_{u_{ij}}$, it was clear that the small $w_{u_{13}}$=can be offset by a relatively large $F_{u_{13}}$. Substituting into the formula for $\hat{F}_{u_{ij}}$, the overall importance weights were obtained:

$$\hat{F}_{u_{11}}=.480,\ \hat{F}_{u_{12}}=.265,\ \hat{F}_{u_{13}}=.203,\ \hat{F}_{u_{14}}=.027, \text{ and } \hat{F}_{u_{15}}=.025.$$

Next the DM's risk-aversion constant for the opportunities and threats was measured using the CE method (step 7). The DM was provided with simple exercises in order to measure his risk-aversion constant towards each opportunity and threat. For example, consider Reduction of Staff (ROS) by 2 percent. The DM was asked to provide his CE for a 50-50 lottery between 0 and 1, where 1 represents the occurrence and 0 represents the non-occurrence of ROS. Given the expected value of .50(1)+.50(0)=.50 for this lottery, the DM was asked to provide his CE between 0 and .50. Note that 0 represents complete risk-aversion ($r=\infty$) and .50 represents complete risk-neutrality ($r=0$). Given the DM's CE of .40 for this lottery and his utility function of $u(.4)=1/r(1-e^{-.4r})$, his risk-aversion constant for ROS was equal to .8. A computer program was used to graphically measures the risk-aversion constant for the opportunities and threats. The program presented the DM with the 50-50 ROS lottery described earlier. Using the graphical scale shown below, the DM could move away from the default complete risk-neutral position (CE=.50, r=0) towards complete risk-aversion position (CE=0, $r=\infty$).



Once the DM placed the cursor at the desired position (CE=.4), the program automatically calculated the risk-aversion constant (r=.8). This procedure was repeated until the risk aversion constants for all opportunities and threats were determined.

These risk-aversion constants along with the overall weights of each factor, and the subjective probabilities are listed as a part of Table 6.

The last step (step 8) was to calculate the risk adjusted strategic value for each alternative using equations (6), (7), and (8). This step was also totally automated, and the DM was only provided with the risk-adjusted opportunity, threat, and strategic values for each alternative. In addition, the system provided the DM with a rank order of the alternatives according to their risk-adjusted strategic values. A spreadsheet was used to manipulate the previously stored weights, probabilities, and risk-aversion constants. Comparisons of the risk-adjusted strategic values indicated the relative desirability of one alternative over others. As shown in Table 6, alternative A had the highest risk-adjusted strategic value (.452) followed by alternative D (.321). Alternatives B and E yielded risk-adjusted strategic values of .274 and .187, while alternative C yielded a negative risk-adjusted strategic value of –.316. Based on these calculations the most attractive alternative was A, followed by Alternative D.

MANAGERIAL SIGNIFICANCE

Global competition, advances in computer technology, and availability of data have made strategic decision making more complex and more critical than ever. Schoemaker and Russo [47] argue that as the significance and the complexity of a decision problem increases, so does the importance of the solution quality. While intuition and simple rules are still favorite decision-making methods, they may be dangerously inaccurate for complex decision problems. SAM is a MAU model that can help DMs improve their decision quality when they are confronted with complex problems like strategy selection. SAM helps DMs (1) ensure the consistency and completeness of the required information and (2) synthesize a vast amount of information into a manageable and easy to understand format. Similar models have been effectively applied to a wide range of complex strategic decisions [29] [47].

The analytical processes in SAM help a DM decompose the complex problem of strategy evaluation into manageable steps. SAM uses environmental scanning, AHP, entropy, and utility theory to help a DM crystallize thoughts and reduce inconsistencies at each step of the process. The strategic evaluation models that are similar to SAM tend to oversimplify the problem description. However, SAM manages the complex task of strategy evaluation without overly simplifying the problem description. In addition, the existing methods treat opportunity and threat factors as the broad environment of the organization. SAM treats these factors as problem-specific items and helps to manage them by grouping these factors into three categories. Finally, the attractiveness of any alternative depends upon the risk-taking capability of the DM. Therefore, the use of a utility function to integrate the DM's risk aversion factor into the rank ordering of the alternatives is expected to enhance the decision quality.

Although the technical details of SAM are complicated and potentially overwhelming for a DM, the concepts are not difficult. The analytical tools and techniques may require some technical assistance from the experts [47]. For example, using AHP to estimate the initial weights of the opportunities and threats requires very little training. The DM using software package such as Expert Choice can make pairwise comparisons on the screen while the complex mathematical manipulations are performed by the computer. In this case study, when SAM was implemented with appropriate user interface, the technical details became transparent to the DM. It also made "what-if" analysis a practical step in strategy selection.

CONCLUSION AND FUTURE RESEARCH DIRECTIONS

SAM decomposes a strategic problem into clearly defined components in which all alternatives, factors, weights, and probabilities are depicted. Next, objective information and subjective judgments of experts are integrated by utilizing several methods of problem structuring and information processing. This decomposition and evaluation is not intended to replace the DMs, rather, it provides a systematic approach to support, supplement, and ensure the internal consistency of their judgments through a series of logically sound techniques. Listed below are some obvious attractive features.

1. SAM stratifies the information requirements into a hierarchy that simplifies information input and helps focus DMs on a small area of the large problem. This process can also help by dividing the problem into different levels of detail for purposes of seeking input from different levels of managers in the organization.
2. Inconsistencies are inevitable while dealing with subjective information from different DMs. The built-in inconsistency checking mechanism of AHP helps in identifying inconsistencies in judgments at very early stages of the computation process.
3. Decision-relevant information about the strategic alternatives is transmitted through their environmental opportunities and threats. However, can the differences in the importance of opportunities and threats be captured fully by their weights or are they implicitly reflected in their probabilities of occurrence? SAM helps bridge the two concepts by enabling DMs to assess the relative weight of different opportunities and threats by the richness of their probability range. The more divergent the probability range of an opportunity or threat, the more information is emitted by it, and the more important it becomes in influencing strategic choice.
4. This approach can be utilized very easily on a PC because software packages for AHP such as Expert Choice are readily available and the use of SAM in an interactive format requires only some additional coding. We have implemented SAM but the current implementation does not have automatic interface with Expert Choice.
5. This model can be used in an interactive mode to deal with "what-if" situations, giving DMs a tool to evaluate alternatives in widely varied environmental scenarios.
6. There are no limits to the number of strategies and the number of factors that can be considered.

On the other hand, SAM only addresses some of the problems inherent in the strategic evaluation process. Quantification of all opportunities and threats is a difficult task. Storing information generated during a session for use in future sessions along with information on actual performance of the selected strategy can facilitate the process of learning from past mistakes. This may be done by interfacing SAM with knowledge-based systems for fine tuning weights and subjective probabilities, and to infer in a non-algorithmic way, for example, by inductive reasoning. Neural networks also offer a potential for developing knowledge-based models in this area. SAM presents a step towards developing a more comprehensive model of strategic evaluation.

Finally, using a structured framework like SAM does not imply that we believe strategic decision making is deterministic. While the framework enables DMs to organize their beliefs, it should be used very carefully. SAM uses an exponential utility function because it is the simplest model of risk aversion and is not subject to the DMs wealth. However, in reality, many strategic decisions are subject to or conditioned by the firm's wealth position. While the exponential utility function is a good starting point, more complex utility functions need to be considered for DMs in firms where wealth is an important factor. Furthermore, managerial judgment is an essential element of SAM. Consequently, the effectiveness of the model relies heavily on the DM's cognitive abilities to provide valid judgments. SAM considers subjective estimation of probabilities and weights since they cannot be supported by empirical analysis. While these judgments can often mirror a DM's reflection or belief in the importance of certain environmental events, they should be used with caution. As with all the other decision calculus models, it is vital that the researchers and practicing managers remain aware of the limits of subjective estimates used in these models. When empirical analysis is feasible and makes economic sense, it should be utilized to improve these estimates [31]. SAM should not be used to plug-in numbers and crank-out optimal solutions. Potentially, DMs could make bad judgments as they do with any framework. Such judgments can generate misleading results and ultimately poor decisions. Fortunately, with the availability of computers, DMs can perform sensitivity analysis and evaluate its impact on various alternatives.

The model presented in this paper deals with the decision-making process of one DM. In reality, strategic decisions are rarely made by a single DM. The next step in enhancing the model will be to extend the model's capabilities to handle input from multiple DMs and summarize their input for strategy selection. The current enhancements in group decision support systems (GDSS) provide a wide range of options to extend the model in the future. We plan to extend SAM to a multiple criteria, multiple DM model for a GDSS environment. [Received: February 18, 1993. Accepted: December 12, 1994.]

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