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Madjid Tavana  
*LaSalle University*

Snehamay Banerjee  
*Drexel University*

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# A case study in multiple criteria decision support systems

Madjid Tavana  
LaSalle University  
Snehamay Banerjee  
Drexel University

## ABSTRACT

*Evaluation of strategic alternatives is an important task for strategic managers. This is a difficult task due to inherent complexities of the evaluation process and lack of structured information. The evaluation process must consider external opportunities and threats, and internal strengths and weaknesses. This paper presents a case study in multiple criteria decision support systems. The decision support system presented in this paper utilizes the model presented in the appendix along with several computer systems including EXPERT CHOICE and Spreadsheets to enhance and aid the decision maker's intuition in evaluating potential alternatives.*

## INTRODUCTION

Philadelphia City Hospital (PCH) is one of Pennsylvania's leading service providers in the health care industry. PCH has continuously demonstrated that their efforts effectively address significant societal needs.

PCH contributes within their means, to the advancement of research, education and health care. This clinical care benefits the people of their neighborhood, city and state. With greater demands being placed upon the hospital from all sectors, PCH and their health care professionals face more restrictions from government and private sectors. Thus, the task of managing the hospital has grown more challenging, at the very time when they have greater potential to do more good for more people than ever before in history.

The hospital's fiscal 1994 operating budget preparation must respond to actual and anticipated nationwide changes in reimbursement for education, research and health care. The proposals that are heard about on a daily basis surround the challenge of controlling cost. These proposals include an emphasis on managed care competition, shift in research funding from hospital to industry, increased support of applied versus basic science research, a global budget for health care, the taxing of health care benefits, price controls and reduction in reimbursement for graduate medical education.

The State legislature has also eliminated all moneys traditionally awarded to private universities resulting in over a \$10 million loss in funding for PCH. Furthermore, there is increased awareness of health care costs in the business community as corporations are forced to include the cost of health care benefits for their retired employees in their annual financial statements. In addition, the business community wants to bargain for health care. All of these reductions plus threatened ones will have a significant impact on PCH's operating budget.

Assuming that current government policies remain in force and that medical practice and private health insurance trends continue, it is projected that national health spending will reach 18% of the gross domestic product by the year 2000. Total spending on health is projected to reach almost \$1.7 trillion in year 2000, compared with about \$800 billion in 1992.

Private health insurance benefits for personal health care will expand from \$186 billion in 1990 to \$450 billion in 2000 and administrative and net underwriting costs will remain a constant 17% of benefits paid. It is also projected that the total number of individuals covered by employer-sponsored insurance will grow slowly in the 1990s. The total employer-sponsored coverage is expected to increase from 135 million people in 1980 to about 145 million in 2000. The number of people with individual insurance (including all insurance not organized through employment) is expected to continue falling in the 1990s from about 17 million in 1990 to 15 million in 2000.

Governments will pay a larger fraction of U. S. health spending through the Medicare and Medicaid programs. Higher government spending on health care has serious implications for the federal budget; the projected increase in health care spending outpaces the growth in any other major component of the budget and promises not only to preempt resources from other government programs, but also to make deficit reduction more difficult.

City has expressed that the health care system as currently financed and organized is plagued by increasing costs at unsustainable rates. Thus, concerned individuals cannot be sure that they will have health care coverage when they need it.

In summary, everyone has seen the numbers: \$750 billion spent annually on health care costs; 35 million people uninsured; \$20 billion to \$150 billion of waste and unnecessary testing and procedures. Between 1992 and 2000, it is anticipated that spending on health care will grow at an average annual rate of 9.6%, almost 4 percentage points faster than the projected GDP growth of 5.8%.

Therefore, the health care system is under reform so that all families have access to affordable high-quality health care. Thus, President Clinton's Health Care Reform Plan is in progress.

To date, President Clinton's Health Care Plan is vague. However, an overview of his expected plan indicates a tightly contained cost environment which guarantees coverage for everyone, while preserving the private health system's quality of choice.

Given the current situation, PCH must decrease their operating budget by \$20 million. Despite this reduction, it is important that the hospital continues to remain a leader in the health care industry during this period of change.

This crisis has been communicated to managers of all cost centers. Administrators from the Fiscal Services Department have been instructed to decrease their budget by 4.5%. Other than having to decrease operating expenses, the department's administrators must strategically evaluate their planned goals and objectives. In retrospect, they must continue to make necessary services available to their customers, as well as preserve or improve the quality of patient care.

## 1. Alternative Courses of Actions

During this period of change PCH must decrease costs, while continuing to ensure that necessary services are available and that the quality of patient care is preserved or improved.

Therefore, it should come as no surprise that the hospital's immediate goal of cost reduction is their first and foremost goal (60% of operating expenses is wages, salaries and benefits). Simultaneously, each department must evaluate their 1994 goals and objectives and consider not only cost, but to what degree they will be able to maintain services and preserve or improve care. The strategic group has identified the following five mutually exclusive alternatives:

### **Alternative A: Implementation of an Electronic Billing System**

Implementation of an electronic billing system for the purpose of automatic claim submission should prove beneficial. For a minimal cost, computer equipment can be installed and employee training can be conducted by information systems personnel. Once the electronic system is operational, manual labor is reduced and the hospital places itself in a better position of being able to adhere to the legislative and regulatory proposals that have emerged in Washington recently. This option of automatic claims submission will reduce labor hours and enable the hospital to reduce their days in accounts receivable.

### **Alternative B: Centralization of the Decentralized Business Offices**

Currently, there are four (4) Decentralized Business Offices on each patient floor. Each patient floor functions as a mini hospital. The decentralization concept has both pros and cons, but in a period of cost reduction, it appears that the disadvantages of having a decentralized concept outweighs the advantages. Centralization will reduce direct cost, increase economies of scale and improve employee morale. In addition, the need for supervisory support is reduced. Patients can be serviced just as well or better under the centralization concept.

Centralization of services must be considered on a case by case basis, because there are instances where having a decentralized environment is clearly more advantageous than a centralized environment.

### **Alternative C: Development of an Economically Feasible Observation Unit**

As a result of a review during last year's (fiscal year 1993) operating budget process, the CEO requested that a study be prepared to determine if an observation unit could be operated without incurring a deficit. It is evident that PCH can benefit by implementing a careful and aggressive observation status program.

There are patients who report for treatment who do not require admission into the hospital nor do they require emergency care. However, their symptoms require that they be observed. Physician's can use observation status to give themselves time to examine patients or determine the need for inpatient admission.

#### **Alternative D: Implementation of Patient Centered Care Programs**

A patient centered care program is a method of redesigning patient care so that hospital resources and personnel are organized around patients rather than around various specialized services. The design of patient care programs if implemented successfully can reduce staff turnover, employee errors and patient length of stay averages—thereby reducing costs. In addition, waiting times for activities such as outpatient registration and the process time for services such as pharmacy and lab can be reduced. Even though this type of program reduces costs, management anticipates that it will also improve delivery systems while increasing physician, staff and patient satisfaction.

#### **Alternative E: Implementation of Managed Care Business**

Managed care refers to the kind of care provided by Health Maintenance Organizations (HMOs) of various types and by Prospective Payment Organizations (PPOs), both of which limit the patient's choice of physicians in an organized system of care. It also refers to the care provided by indemnification insurance plans that offer a free choice of physicians, but manage care by monitoring claims and denying or reducing payment for those deemed unjustified.

It is suspected that the cost to treat an HMO patient is less than the cost of treatment for patients insured by a more traditional plan. Moving in a direction of managed competition may result in more people becoming insured under managed care contracts. This will result in hospitals becoming more competitive with one another. Whereas, hospitals such as Philadelphia City could lose business, because their costs are higher than their local competitors'.

## **2. Environmental Factors**

After careful analysis of the situation, management has identified a list of opportunities and threats and categorized them into internal, transactional, and contextual environments. This list is presented in Table 1. A detailed description of each factor is given below:

**Table 1. Environmental Opportunities and Threats****OPPORTUNITIES****Internal Environment:**

- ROS: Reduction of Staff by 2%
- IIP: A Minimum of 5% Increase in Productivity
- ESL: An Above Average Increase in Employee Skill Level
- COM: Improving Communications
- ICS: Improving Customer Service to Above 90 Points Level

**Transactional Environment:**

- HQC: Ability to Provide Above Industry Average Quality Patient Care
- PHR: Improving Hospital and Physician Community Relationships
- IMS: Ability to Increase Market Share by 8%
- MCB: A 10% Increase in Managed Care Business
- IOS: An Increase in Outpatient Services by 6.5%

**Contextual Environment:**

- RGC: Ability to Respond Favorably to New Governmental Changes
- GFA: Increase in Government Financial Assistance to Uninsured Persons
- AGL: Availability of Special Government Loans

**THREATS****Internal Environment:**

- RTC: Employee/Physician Resistance to Change
- IEX: An Above Average Increase in Educational Expenses
- RDE: Placement of Displaced Employees Within the Hospital
- LAS: Lack of Available Office Space

**Transactional Environment:**

- NPH: Negative Perception of the Hospital
- RIS: Reduction of Inpatient Services by Over 5%
- SAD: Majority of Short-stay Admissions Denied Causing Review Intensification
- CSU: Possibility of Clerical Staff Joining the Union
- ILC: Possibility of an Above Average Increase in Litigation Cases

**Contextual Environment:**

- TMC: Threat of Managed Competition
- RIP: Lower Reimbursement Due to Revised Insurance Payment Schedules
- RGR: Lower Reimbursement Due to New Governmental Regulations

## **Internal Opportunities:**

### *ROS: Reduction of Staff by 2%*

During this time of change, one of our biggest challenges is to reduce costs. Because wages, salaries and benefits represent 60% of overall expenses, it is essential that a reduction in staff become the hospital's immediate focus point. The anticipated fiscal year 1994 target for the Fiscal Services Division is a 2% staff reduction. This 2% decrease in staffing will result in an expense reduction of \$486,000. Approximately 26.4% of the \$486,000 is representative of benefits and the remaining dollars for wages and salaries. Several of the projects under evaluation will also enable PCH to meet this goal.

### *IIP: A Minimum of 5% Increase in Productivity*

After some research it is expected that the hospital can increase productivity by a minimum of 5%. This increase will result from management and employees evaluating their processes to streamline or even eliminate duplication and/or unnecessary procedures without lessening quality. In addition, leaders have been sensitized about building psychological structures for followers (employees) by assigning particular tasks, specifying procedures, clarifying expectations and scheduling work to be done. Leaders must also create, if they haven't already, an environment that renders warmth and helpfulness. This can be accomplished by being friendly and approachable, as well as by looking out for the welfare of subordinates, going to bat for them and representing their interests upward. Increasing productivity is an important factor in our ability to meet the demands that will be placed upon us.

### *ESL: An Above Average Increase in Employee Skill Level*

Due to a reduction in the work force, it is possible that job responsibilities will be expanded, thus increasing employee skills levels. This can be accomplished by combining tasks, forming identifiable work units, establishing client relationships, vertically loading jobs and assuring that there is open feedback channels.

### *COM: Improving Communications*

PCH conducted an employee survey and one of the problems as determined by the employees was a lack of communication. Improvement in this area has the potential to enhance relationships between employees, management, physicians, administrators, etc. The hospitals' administrators have instituted programs and management update meetings to facilitate positive work outcomes, positive feelings and positive relationships, thus fostering better communications.

### *ICS: Improving Customer Service to Above 90 Points Level*

Research in the areas of arrival and patient wait times, courtesy of staff, comfort of facility and waiting areas, as well as the overall knowledge of staff members demonstrate that improvement is necessary. The hospital's score for the above factors total 77. It is felt that this score should be in the high 90s. Therefore, the hospital is in the process of implementing a "STAR" Program. "STAR" stands for sensitivity, teamwork, awareness and respect.

**Transactional Opportunities:***HQC: Ability to Provide Above Industry Average Quality Patient Care*

Measuring quality of care is a very difficult task. People have the tendency to focus on the physician's ability to help cure the disease and alleviate the pain as the only benchmark. One rarely thinks about how captive relationships, data collection, rapidly changing technology, costs and primary care relationships are related to providing high quality patient care. To put it simply, individuals don't generally see the benefits they receive from any nonmedical services. The hospital has taken a hard look at payment reform. It is felt that despite cutbacks, every department must evaluate their ability to provide high quality care. This is very important to PCH. This factor determines if patients, customers, insurance companies, and vendors want to do business with Philadelphia City Hospital. Results from these factors can be a reflection of how Philadelphia City Hospital is perceived by its community.

*PHR: Improving Hospital and Physician Community Relationships*

In the past administrators and physicians have had different views due to their different socialization processes. Physicians have a unique socialization process due to their expectations in medical schools and residencies. They are taught to take control and function autonomously, instead of thinking of themselves as part of an overall system of care. The time has come where it is important to involve physicians in TQM, because in the future practice guidelines will be tied to reimbursement. As a result of this anticipated change, the hospital has implemented a TQM program that will involve physicians as early as possible. The hospital will begin this process with a noncontroversial area in order to minimize defensiveness until more physician support is gained. In essence, improved physician/hospital relationship is critical as we move into an era of health care reform. In the long run, enhanced relationships will benefit the patients, physicians and hospital.

*IMS: Ability to Increase Market Share by 8%*

The hospital's competitors and the health care industry itself are being studied. It is a realistic goal that the hospital can increase their business by 8% through new and enhanced programs, as well as by being cost conscious. Being a visionary while minimizing cost will prove beneficial to the institution.

*MCB: A 10% Increase in Managed Care Business*

Currently 4% of our business is with managed care plans. As a result of President Clinton's proposed plan, it is felt that most insurance plans will be in the form of managed care. The hospital may begin to meet with insurance companies in an attempt to negotiate contracts that will increase managed care business by 10% during fiscal year 1994.

*IOS: An Increase in Outpatient Services by 6.5%*

It goes without saying that outpatient services are increasing. Economic forces will continue to push care to the outpatient setting. Our estimation is that outpatients will increase by 6.5% or more by the end of fiscal year 1994.



### **Contextual Opportunities:**

#### *RGC: Ability to Respond Favorably to New Governmental Changes*

This factor is the most critical of the contextual environment. Short- and long-term strategies formulated to safeguard PCH are already being addressed. Many of the strategies outlined within the opportunities are already in progress.

#### *GFA: Increase in Government Financial Assistance to Uninsured Persons*

PCH is putting its best foot forward. It is felt that the uninsured population will eventually become insured. As a result, PCH could increase their net operating income as long as there is a corresponding reduction in costs. Currently about 15% of the patients serviced are classified as self-pay. Some charges are written off to bad debt or free care, because there is no means of collection. Even if we are reimbursed minimally from an expanded government entitlement program, PCH may recoup some of the charges previously written off.

#### *AGL: Availability of Special Government Loans*

This factor was also considered important in the decision making process since some of the funding could be supported through various government loans.

### **Internal Threats:**

#### *RTC: Employee/Physician Resistance to Change*

Faced with increasing fragmented, rapidly changing, tumultuous conditions, the staff must become aware of their orientation towards change. The possibility of employee/physician resistance does exist. The hospital's employees/physicians are use to and comfortable with a stable environment. Therefore, in this environment of rapid change, people are more likely to feel uncomfortable. As a result of feeling uncomfortable, the staff may perform ineffectively and may not understand the point of view of those whose perspective differs from theirs.

#### *IEX: An Above Average Increase in Educational Expenses*

Due to budget constraints, increased educational expenses will have a negative effect on the hospital's goal of cost reduction. The benefits of training and educating the staff must be weighed against the down side which is an increase in educational expenditures.

#### *RDE: Placement of Displaced Employees Within the Hospital*

There is a possibility that employees who will encounter a layoff will be entitled to interview for available jobs for which they qualify. The hospital currently has a hiring freeze and no jobs can be filled unless there is administrative (Senior Level) approval. Therefore, the probability of displaced employees being hired for another job is minimal. This may be detrimental to the morale of other employees, thus having a considerable impact on the efficiency of the organization.

***LAS: Lack of Available Office Space***

With decisions being made to become more cost effective, chances are that some of the decentralized services will become centralized. Thus, smaller office spaces may have to be traded for larger ones. This is a problem, since space allocation is scarce. The possibility exists that a good concept that promotes quality of care and reduces costs may not be implemented due to the lack of available space.

**Transactional Threats:*****NPH: Negative Perception of the Hospital***

The PCH realizes that the media may publish information about area hospitals. This published information may prove beneficial to some hospitals and detrimental to others. It is felt that as President Clinton approaches the date in which his plan will become reality, the tendency for the media to publish cost information, mortality rates, etc., in an attempt to compare hospitals and implant negative thoughts in an employee's mind will come to fruition. These kinds of controversial subjects could pose a negative perception on PCH, especially since the hospital has higher costs.

***RIS: Reduction of Inpatient Services by Over 5%***

As previously stated, there is a push towards more outpatient services. Due to advanced technologies, people don't have to remain in the hospital overnight. This reduction in inpatient services poses a threat, because much of PCH's revenues come from charges incurred during hospitalizations. This may have an immediate and substantial impact on their net operating income.

***SAD: Majority of Short-stay Admissions Denied Causing Review Intensification***

Also related to the fact that there is a decrease in hospitalizations, short stays are being denied by third party payers. Medical records are being reviewed carefully to ensure that short stays are medically necessary. Denials based on probable changes in regulations related to short stay admissions result in insurance payment denials. This could have a negative impact on the hospital.

***CSU: Possibility of Clerical Staff Joining the Union***

Due to staff reductions, increased responsibilities, threat of anticipated changes, etc., there is a possibility that our nonunion clerical staff will contemplate joining the union. In these critical times, the hospital will benefit by dismissing the least competent of its employees and retaining as long as possible those who have proven themselves to be better workers. However, nonunion employees may show signs of empathy. Whereas, nonunion employees may view the union as having power over and protection of their members, thus making the union appealing enough to join.

*ILC: Possibility of an Above Average Increase in Litigation Cases*

Research reveals that Bill Clinton's election victory could mean an increase in antitrust suits. There is a possibility that cost control efforts will increasingly end up in court.

**Contextual Threats:**

*TMC: Threat of Managed Competition*

There is reason to be concerned about how managed competition would work. Managed competition could have an effect on the quality of care. If the rise in prices were constrained by competition, one way of maintaining profits would be to limit services. However, with managed competition, the responsibility for management is in the hands of third parties rather than in the hands of doctors.

*RIP: Lower Reimbursement Due to Revised Insurance Payment Schedules*

Lower reimbursement poses a threat, because a decrease in payments and an increase in discounts and allowances will reduce the hospital's net operating income.

*RGR: Lower Reimbursement Due to New Governmental Regulations*

Lower reimbursement due to new governmental regulations poses a similar threat as lower reimbursement resulting from new payment schedules.

Next, using Analytic Hierarchy Process (AHP), the strategic group developed environmental-related weights for both opportunities and threats. In discussing the relative importance of the different opportunities, internal, transactional and contextual, it soon became clear that the internal opportunities outweigh the transactional and contextual opportunities. Furthermore the management was able to show that the transactional threats are more significant in the evaluation process. In addition the judgements and priorities for the opportunity and threats factors were also processed and developed with AHP. Much of this was based on anecdotal evidence, which was articulated through a series of meetings of the top management. The sorted details of the pairwise comparisons and weights for opportunities are given in Table 2 and the same for threats are given in Table 3.

**Table 2. Pairwise Comparison Matrices (Opportunities)**

ENVIRONMENTAL COMPARISONS  
INCONSISTENCY RATIO = 0.037

|               | INTERNAL | TRANSACTIONAL | CONTEXTUAL | RELATIVE WEIGHT |
|---------------|----------|---------------|------------|-----------------|
| Internal      | 1        | 3             | 5          | 0.637           |
| Transactional | 1/3      | 1             | 3          | 0.258           |
| Contextual    | 1/5      | 1/3           | 1          | 0.105           |

INTERNAL FACTORS  
INCONSISTENCY RATIO = 0.038

|     | ROS | IIP | ESL | COM | ICS | RELATIVE WEIGHT |
|-----|-----|-----|-----|-----|-----|-----------------|
| ROS | 1   | 3   | 4   | 5   | 7   | 0.484           |
| IIP | 1/3 | 1   | 3   | 4   | 5   | 0.262           |
| ESL | 1/4 | 1/3 | 1   | 2   | 4   | 0.131           |
| COM | 1/5 | 1/4 | 1/2 | 1   | 2   | 0.077           |
| ICS | 1/7 | 1/5 | 1/4 | 1/2 | 1   | 0.046           |

TRANSACTIONAL FACTORS  
INCONSISTENCY RATIO = 0.027

|     | HQC | PHR | IMS | MCB | IOS | RELATIVE WEIGHT |
|-----|-----|-----|-----|-----|-----|-----------------|
| HQC | 1   | 2   | 4   | 6   | 8   | 0.460           |
| PHR | 1/2 | 1   | 3   | 4   | 6   | 0.288           |
| IMS | 1/4 | 1/3 | 1   | 3   | 4   | 0.142           |
| MCB | 1/6 | 1/4 | 1/3 | 1   | 2   | 0.068           |
| IOS | 1/8 | 1/6 | 1/4 | 1/2 | 1   | 0.042           |

CONTEXTUAL FACTORS  
INCONSISTENCY RATIO = 0.077

|     | RGC | GFA | AGL | RELATIVE WEIGHT |
|-----|-----|-----|-----|-----------------|
| RGC | 1   | 7   | 6   | 0.760           |
| GFA | 1/7 | 1   | 2   | 0.144           |
| AGL | 1/6 | 1/2 | 1   | 0.096           |

**Table 3. Pairwise Comparison Matrices (Threats)**

ENVIRONMENTAL COMPARISONS  
 INCONSISTENCY RATIO = 0.031

|               | INTERNAL | TRANSACTIONAL | CONTEXTUAL | RELATIVE WEIGHT |
|---------------|----------|---------------|------------|-----------------|
| INTERNAL      | 1        | 7             | 4          | 0.079           |
| TRANSACTIONAL | 1/7      | 1             | 3          | 0.659           |
| CONTEXTUAL    | 1/4      | 1/3           | 1          | 0.262           |

INTERNAL FACTORS  
 INCONSISTENCY RATIO = 0.045

|     | RTC | IEX | RDE | LAS | RELATIVE WEIGHT |
|-----|-----|-----|-----|-----|-----------------|
| RTC | 1   | 3   | 5   | 7   | 0.568           |
| IEX | 1/3 | 1   | 3   | 4   | 0.252           |
| RDE | 1/4 | 1/3 | 1   | 2   | 0.121           |
| LAS | 1/5 | 1/4 | 1/2 | 1   | 0.059           |

TRANSACTIONAL FACTORS  
 INCONSISTENCY RATIO = 0.020

|     | NPH | RIS | SAD | CSU | ILC | RELATIVE WEIGHT |
|-----|-----|-----|-----|-----|-----|-----------------|
| NPH | 1   | 2   | 3   | 5   | 7   | 0.429           |
| RIS | 1/2 | 1   | 3   | 4   | 6   | 0.303           |
| SAD | 1/3 | 1/3 | 1   | 2   | 4   | 0.143           |
| CSU | 1/5 | 1/3 | 1/2 | 1   | 2   | 0.079           |
| ILC | 1/7 | 1/6 | 1/4 | 1/2 | 1   | 0.046           |

CONTEXTUAL FACTORS  
 INCONSISTENCY RATIO= 0.037

|     | TMC | RIP | RGR | RELATIVE WEIGHT |
|-----|-----|-----|-----|-----------------|
| TMC | 1   | 3   | 5   | 0.637           |
| RIP | 1/3 | 1   | 3   | 0.258           |
| RGR | 1/5 | 1/3 | 1   | 0.105           |

### PROBABILITIES

Next the decision makers were asked to estimate initial occurrence probabilities of all opportunity and threat factors using the verbal probabilistic phrases and their perceived probability estimates given in Table 4 as guidelines. These probabilities indicate the likelihood that each factor will occur in the future. This subjective probability estimation is based on the decision maker's intuition and expertise.

**Table 4. Verbal Probabilistic Expressions and Perceived Probability Estimates**

| <u>Verbal Expression</u> | <u>Probability</u> |
|--------------------------|--------------------|
| Impossible               | 0.00               |
| Small Possibility        | 0.10               |
| Small Chance             | 0.20               |
| Somewhat Doubtful        | 0.30               |
| Possible                 | 0.40               |
| Toss-Up                  | 0.50               |
| Somewhat Likely          | 0.60               |
| Likely                   | 0.70               |
| Very Likely              | 0.80               |
| Quite Certain            | 0.90               |
| Certain                  | 1.00               |

#### Alternative A:

In analyzing whether or not to implement an electronic billing system, it is believed that National Electronic Information Corporation (NEIC), a nationwide electronic claims collection and distribution system will be a valuable asset to the hospital. Start-up costs for equipment is minimal.

The NEIC system will necessitate a change in the way employees do business. A reduction of staff (ROS) by 2% is quite certain (90%), because NEIC tremendously reduces the number of paper bound steps between the health care provider's submission of claims and its payment. As with most individuals, there is often some possible resistance to change. Even though employee/physician resistance to change (RTC) is possible (40%), it is expected that this resistance will not be permanent as employees familiarize themselves with the equipment and realize that workload will decrease by about 30%. Furthermore, management believes that it is likely (70%) for this alternative to increase productivity (IIP) by a minimum of 5%.

With this electronic processing system claims are submitted electronically to NEIC where they are reedited, sorted and distributed to participating insurance carriers. Each claim is edited

for completeness, logic and proper format; responsibilities previously held by employees. The only time claim submission requires human intervention is when clerical errors or missing information are identified through provider reports sent back to the hospital. In turn, the rejected claims can be corrected and resubmitted to NEIC.

Installing this equipment is somewhat likely (60%) to increase employee skill level (ESL) as individuals master this new technology. It is expected that installing this PC based claim processing system will possibly (40%) improve communications (COM) and is very likely (80%) to improve customer service (ICS).

A part of providing high quality care also entails the back end departments who have very little to do with a patient's direct care. Being able to streamline processes such as the billing process is very likely (80%) to enhance the hospital's ability to provide high quality care (HQC). For instance, uniformity in data collection methods and analytical techniques may not mean anything to a patient; however, health information is required to better comprehend the nation's health care system in an attempt to provide quality care. In pursuit of this goal, a forum for information exchange among data collectors, systems and users are a way to improve the quality and use of health care delivery.

It is possible (40%) that physician/hospital relationships (PHR) may improve due to the installation of this billing system, because the quality of data entered by the hospital may directly impact the reimbursement for professional fees as well. Generally speaking, a professional charge (physician charge) often follows a technical charge. Thus, accurate information entered by the hospital staff results in a smoother process for the physician billing cycle. There is a small chance (20%) that an increase in outpatient services (IOS), market share (IMS), and managed care business (MCB) will occur with the installation of NEIC.

It is quite certain (90%) that the installation of NEIC will have an effect on the hospital's ability to respond favorably to new government changes (RGC) and increased business. In fact, NEIC is currently promoting a new version of software that has the capability to handle all third party claims. This idea seems to be a direct result of the legislators and government push to streamline paper and unify data. In addition, it is believed that an increase in government financial assistance to uninsured persons (GFA) is likely (70%) to occur if this alternative is implemented.

Due to the anticipated reduction in staff that is directly related to the estimated decrease in manpower needed to process claims, it is very like (90%) that human resources will have to explore replacing some of the displaced employees (RDE). As a result of this potential layoff, it is possible (40%) that employees will become resistant to the change (RTC) in new billing procedures. There is also a small chance (20%) that the budget for educational expenses (IEX) will increase, because the cost of training has been incorporated into the price of the equipment. An advantage is that the equipment is compact, thus the possibility of the lack of office space (LAS) is small (10%). The probability of occurrence for negative perception of the hospital (NPH), short-stay admissions denied (SAD), increase in litigation cases (ILC), threat of managed competition (TMC) and new government regulations (RGR) are estimated to be small (10%) while the probabilities of reduction of inpatient services (RIS), clerical staff joining union

(CSU), availability of special government loans (AGL) and revised insurance payment schedule (RIP) are estimated to be somewhat higher at 20%.

### Alternative B:

For the past 10 years, there have been four (4) decentralized business offices located on each patient floor. Even though this concept is very convenient for patients, it is also very costly. For example, each Decentralized Business Office has a supervisor and a receptionist. If one centralizes the offices, it is quite certain (90%) that the staff (ROS) can be reduced by approximately 12.5%. It is very likely (80%) that a move towards centralization will also increase productivity (IIP), better communications (COM) and improve customer services (ICS). In turn the department has more economies of scale. In addition employees don't have to be a jack of all trades.

Currently, the employees in each decentralized business office must know in detail the numerous tasks that come with the jobs. As a result of a centralized work environment, specialization of job responsibilities can occur. Thus, there is a small possibility (10%) that an individual's skill level (ESL) will be broadened.

PCH is quite certain (90%) that the high level of quality care (HQC) will be maintained. There is only a small chance (10%) that physician/hospital relationships (PHR) will be improved, because the office staff is moving further away from the physician/nursing units. There is a small possibility (10%) that centralization will also increase business (MCB) and outpatient services (IOS). It is believed that an increase in market share (IMS) is somewhat doubtful (30%) to occur with this alternative.

The contextual opportunities have been evaluated and after careful consideration the management speculates that ability to respond favorably to new government changes (RGC) and increase in government financial assistance to uninsured persons (GFA) are likely (70%) to occur with this alternative.

Since there may be a decrease in the number of individuals employed in this department, the threat of having to find jobs (RDE) for the staff is quite certain (90%). Also, recognizing that there is a lack of available office space (LAS), it is quite certain (90%) that this factor will be a major contributor as to whether or not this alternative can be implemented. The department has to find ample space to accommodate patients, staff and equipment. It is somewhat likely (60%) that by centralizing the office, employees will be adversely affected, thus making employee/physician resistance to change (RTC) a viable issue which must be minimized. Also, if employees are dissatisfied with the reduction in staff and the new work environment, there is a chance that they will join the union. Even though we perceive this as a possibility, the reality of employees joining the union (CSU) is somewhat doubtful (30%).

Employee tasks will become more specialized which could affect employee morale. Employees are already trained; therefore, an increase in educational expenses (IEX) is only a small possibility (10%).



Centralization poses the threat of increased patient wait times and if patients become dissatisfied, it is possible (40%) that there will be a decrease in inpatient services (RIS).

Management has included employees in the process of implementing change. Thus, the chances of this having a negative effect on the hospital's perception (NPH) is somewhat doubtful (30%). The probabilities of occurrence for short-stay admissions denial (SAD), increase in litigation cases (ILC), new government regulations (RGR), revised insurance payment schedules (RIP), availability of special government loans (AGL) and managed competition (TMC) are expected to be small (10%) if this alternative is implemented.

### **Alternative C:**

Hospitals can benefit by implementing a careful and aggressive observation status unit. Achieving a consensus on observation beds has both clinical and reimbursement advantages.

Initially, there is a small possibility (10%) to reduce staffing (ROS), because hospitals are required to staff the unit with a certain number of nurses with varying skill levels. Because this is a new unit, it is vital that it be staffed for peak conditions. There is also a small possibility (10%) of the staff joining the union (CSU). It is believed that the clinical staff assigned to this area would have adequate skills and that there is a possibility (40%) of expanded skill levels (ESL). It is recognized that effective communications between physicians/employees is critical. It is anticipated that there is only a small possibility (10%) of increased productivity (IIP). Communications (COM) may (50%) improve as a result of implementing an observation unit. It is somewhat doubtful (30%) that this unit will result in much customer service improvement (ICS).

It is likely (70%) that physician/hospital relationships (PHR) will improve over the long run as physicians will be provided more time to observe a patient before assigning a diagnosis. This process can significantly improve the integrity of medical records. In many cases, a physician specifies a diagnosis so that a patient can be admitted but later realizes that a different diagnosis should have been utilized. Switching the diagnosis raises questions from the Peer Review Organization. There is only a small possibility (10%) that short stays (SAD) will be denied.

It is somewhat likely (60%) that the hospital will be able to increase their market share (IMS) by freeing up inpatient beds and making them available to other patients. On the other hand, implementing an observation unit may result in reduced inpatient services (RIS), especially if available beds are not occupied. Thus, we are quite certain (90%) that this unit will have an impact on admissions. There is a small possibility (10%) that this observation unit will bring about increased managed care business (MCB), outpatient services (IOS) and high quality patient care (HQC).

PCH is quite certain (90%) that by creating an observation unit, they will be able to respond favorably to new governmental changes (RGC). Logistics is not an issue and appropriate revenue codes are already in the billing system. Furthermore, hospitals have the opportunity to

be reimbursed on a cost basis. At year's end, when cost reports are completed for observation beds and other units under the same reimbursement system, the hospital and the fiscal intermediary will hammer out a settlement based on whether the facility has been under or overpaid.

In summary, an observation unit affords the opportunity to hold and evaluate patients pending disposition (i.e., admission to an inpatient bed, discharge or transfer). The opportunity provides the following benefits:

- Eliminates the need to use an inpatient bed for a stay of short duration, thereby allowing more acute patients to utilize the bed.
- Eases overcrowding in the Emergency Department by providing a specific area for observation pending disposition.
- Prevents third-party payer denial of inpatient stays by providing the alternative of outpatient care.

There is a small possibility (10%) that the hospital will have to be concerned about replacing displaced employees (RDE). It is possible (40%) that there will be some resistance to change (RTC), especially since physicians must be careful not to under document the medical record. In addition, they must document justification of skilled services, such as those provided by nursing. Availability of special government loans (AGL) and an increase in educational expenses (IEX) is somewhat likely (60%) to occur as the hospital attempts to educate physicians and doctors throughout the hospital on observation bed protocol. Lack of available office space (LAS) is very likely (80%) to occur with this alternative.

It is also possible (40%) that patients will view this unit negatively (NPH), due to their lack of understanding the unit's purpose. There is a small possibility (10%) that litigation cases (ILC) and government financial assistance (GFA) will increase.

It is true that governmental regulations and revised payment schedules may change in the future; however, with the implementation of this unit there is a small possibility (10%) of new governmental regulations (RGR) and changes in the insurance payment schedule (RIP). Managed competition (TMC) should also have a somewhat doubtful (30%) probability of occurrence if this alternative is implemented.

### **Alternative D:**

Extensive research has proven that patient-centered care has successfully reduced turnover, employee error and patient length of stay averages. A study of overall hospital environment reveals that it is somewhat likely (60%) that our staff can be reduced (ROS). Customer services (ICS) can quite certainly (90%) occur and waiting times for activities such as outpatient registration can be reduced. Also, the process time for services such as pharmacy and lab can be streamlined. Some patient care programs have even reduced hospital costs.

The redesign of patient care so that hospital resources and personnel are organized around patients will likely (70%) increase productivity (IIP). The management is quite certain (90%)

that skill level (ESL) will increase, because employee job tasks will be desegregated and the staff will receive the necessary support, skills, education and training that is necessary for them to fulfill their responsibilities. It is very likely (80%) that educational expenses (IEX) will increase as a result of this support. New methods for deploying staff, the redistribution of jobs and the restructuring of facilities are just a few examples of what patient-centered care brings about. Furthermore, management believes that ability to increase market share (IMS) and new government changes (RGC) is likely (70%) to occur while an increase in government financial assistance (GFA) and availability of special government loans (AGL) are very likely (80%) to occur.

Patient centered care (HQC) is likely (70%) to bring about the most effective and efficient care to patients as there is vertical and horizontal collaboration among nurses, physicians and technicians. In addition, operational elements are merged. These factors will very likely (80%) foster better communications (COM), as well as improve physician/hospital (PHR) relationships. The management is hopeful that this new intervention will be somewhat likely (60%) to increase the outpatient services (IOS) and very likely (80%) to increase managed care business (MCB).

Some of the other popular characteristics of the program are the development of caregiver team interrelationships, the cross training of staff to create multi-disciplinary teams and increases shared decision making among physicians, nurses and allied health professionals. Thus, it is very likely (80%) that the hospital will incur additional educational expenses (IEX). Management is somewhat doubtful (30%) that replacement of displaced employees (RDE) and an increase in litigation cases (ILC) will occur with this alternative.

It is also likely (70%) that there will be some resistance to this change (RTC), both from employees and physicians. They may feel threatened by the initiatives, uncomfortable at the prospect of shared decision making and fearful of losing their jobs. Thus, it is possible (40%) that the clerical staff may consider joining the union (CSU). This fear can be combatted by intensifying education and communication. After employees/physicians learn more about the patient center care programs and know what to expect, it is possible (40%) that a negative perception of the hospital (NPH) will disappear.

This alternative has a small chance (20%) of lack of additional office space (LAS) and short-stay admissions denied (SAD). In addition, with the successful implementation of this alternative there is only a small chance (20%) that inpatient services (RIS) will reduce. Furthermore, the probability of occurrence of the contextual threats seems to fall below toss-up.

### **Alternative E:**

The decision to market for additional managed care business is one that must be studied very carefully. Currently, many of the managed care plans do not want to do business with PCH because their costs are extremely high. In fact, the hospital's costs are above the 75th percentile in comparison to its competitors, thus managed care plans don't want to contract with them. The probability of being able to compete with area hospitals (IMS) for managed care business having lower costs is somewhat doubtful (30%).

Marketing for increased managed care business is likely (70%) to have an effect on staff reduction (ROS), improved physician/hospital relationships (PHR) and an increase in government financial assistance (GFA). An increase in managed care business will very likely (80%) lower reimbursement due to government or regulatory policies (RGR) surrounding managed care plans and the payments to hospitals resulting from the plan to manage competition.

Managed care patients have significantly shorter intensive care unit (ICU) and hospital stays and corresponding lower costs with no apparent difference in mortality or intensive care unit (ICU) readmission. Average differences of about 30% to 40% have been observed. The differences were more pronounced in patients with the lowest severity of illness.

Generally speaking, the median ICU stay of managed care patients was about 35% shorter than that of traditionally insured patients. The median hospital stay and total charges of managed care patients are about 25% shorter than those of traditionally insured patients.

Controlling for case mix and severity, a managed care patient would stay (on average) about two fewer days in the ICU and five fewer days in the hospital than would a similar patient covered by traditional insurance. There is no difference in mortality of ICU readmission rate between the two groups to suggest a benefit from the additional ICU stay of the insured patients.

PCH realizes their need to reduce patient days; however, they are not certain that increasing managed care business is the way to go about resolving this problem. It is felt that managed care plans force physicians to practice medicine according to business practices vs. medicine.

If decisions are made to increase managed care business, there is a small possibility (10%) that the hospital would decrease inpatient services (RIS), due to the power that these plans have over physicians in terms of who can and cannot be admitted. Furthermore, it is possible (40%) that litigation cases (ILC) will increase because patients may feel that they have been prematurely discharged in an effort to control costs. It is felt that increasing managed care business will have a very small (10%) effect on other transactional threats.

There is a somewhat doubtful (30%) chance that there will be lack of available office space (LAS) and there is also a small possibility (10%) that replacement of displaced employees (RDE) will occur. In addition, it is assumed that the probability of occurrence is quite certain (90%) for new government changes (RGC) while it is very likely (80%) for increase in outpatient services (IOS), availability of special government loans (AGL) and managed competition (TMC).

PCH is quite certain (90%) that, if the decision is made to increase managed care business, increased educational expenses (IEX) will occur, because the behavior of doctors will have to be modified. Physicians who feel that cost-effective care is best defined as the care provided by a competent and compassionate physician who has no incentive to do more or less than is judged appropriate, must now realize that the intrusion of third parties will define cost limits, methods of treatment and overall management of patients. Physicians must be educated in this new way of practicing care. Furthermore, management believes that an increase in managed care business (MCB) and employee/physician resistance to change (RTC) may (50%) occur if this alternative is implemented and the probability of occurrence for an increase in employee skill level (ESL) is small (20%).

One of the biggest advantages will come from the transactional environment which primarily focuses on increasing business. Thus, the hospital is certain that they must compete with other facilities, if they should decide to increase their managed care business through contract

negotiations. An increase in managed care business would mean an increase in services. It is also likely that physician/hospital relationships will improve, because some of the physicians will have to join the managed care networks, as a result of the hospital's administration signing contracts with various plans and deciding that a good deal was initiated. And of course as specified in the hospital's goal of providing quality care, it is very likely (80%) that PCH will continue the trend of treating their patients with high quality care (HQC). The probability of occurrence for all the remaining factors is estimated to be possible (40%).

A summarized listing of initial occurrence probabilities associated with all opportunities and threats for all alternatives is given in Table 5.

**Table 5. Initial Probabilities of Occurrence**

| OPPORTUNITIES             |      |      |      |      |      |
|---------------------------|------|------|------|------|------|
|                           | A    | B    | C    | D    | E    |
| Internal Environment      |      |      |      |      |      |
| ROS                       | 0.90 | 0.90 | 0.10 | 0.60 | 0.70 |
| IIP                       | 0.70 | 0.80 | 0.10 | 0.70 | 0.40 |
| ESL                       | 0.60 | 0.10 | 0.40 | 0.90 | 0.20 |
| COM                       | 0.40 | 0.80 | 0.50 | 0.80 | 0.40 |
| ICS                       | 0.80 | 0.80 | 0.30 | 0.90 | 0.40 |
| Transactional Environment |      |      |      |      |      |
| HQC                       | 0.80 | 0.90 | 0.10 | 0.70 | 0.80 |
| PHR                       | 0.40 | 0.20 | 0.70 | 0.80 | 0.70 |
| IMS                       | 0.20 | 0.30 | 0.60 | 0.70 | 0.30 |
| MCB                       | 0.20 | 0.10 | 0.10 | 0.80 | 0.50 |
| IOS                       | 0.20 | 0.10 | 0.10 | 0.60 | 0.80 |
| Contextual Environment    |      |      |      |      |      |
| RGC                       | 0.90 | 0.70 | 0.90 | 0.70 | 0.90 |
| GFA                       | 0.70 | 0.70 | 0.10 | 0.80 | 0.70 |
| AGL                       | 0.20 | 0.10 | 0.60 | 0.80 | 0.80 |
| THREATS                   |      |      |      |      |      |
| International Environment |      |      |      |      |      |
| RTC                       | 0.40 | 0.60 | 0.40 | 0.70 | 0.50 |
| IEX                       | 0.20 | 0.10 | 0.60 | 0.80 | 0.90 |
| RDE                       | 0.80 | 0.90 | 0.10 | 0.30 | 0.10 |
| LAS                       | 0.10 | 0.90 | 0.80 | 0.20 | 0.30 |
| Transactional Environment |      |      |      |      |      |
| NPH                       | 0.10 | 0.30 | 0.40 | 0.40 | 0.10 |
| RIS                       | 0.20 | 0.40 | 0.90 | 0.20 | 0.10 |
| SAD                       | 0.10 | 0.10 | 0.10 | 0.20 | 0.10 |
| CSU                       | 0.20 | 0.30 | 0.10 | 0.40 | 0.10 |
| ILC                       | 0.10 | 0.10 | 0.10 | 0.30 | 0.40 |
| Contextual Environment    |      |      |      |      |      |
| TMC                       | 0.10 | 0.10 | 0.30 | 0.20 | 0.80 |
| RIP                       | 0.20 | 0.10 | 0.10 | 0.30 | 0.40 |
| RGR                       | 0.10 | 0.10 | 0.10 | 0.40 | 0.80 |

Once the initial probability sets are determined, we used cross-impact analysis to capture the interactions among these factors. The conditional probabilities shown in conditional probability matrices are estimated in response to the question "if one factor occurs, what is the new probability of the second factor in the same environment?"

Therefore, if for example the probability of ROS was originally judged to be 0.90, it might be judged that the probability of this factor would be 0.95 if IIP occurs. Or, it might be judged that the probability of ROS would be 0.85 if ESL occurs. The entire matrix is completed by asking the question for each combination of occurring factors. Then these estimates are checked to see whether they fit the limits for consistency. For example, the limits for the probability of ROS given the occurrence of IIP are 0.86 and 1.00 ( $\frac{P(\text{ROS}) - 1 + P(\text{IIP})}{P(\text{IIP})} \leq P(\text{ROS}/\text{IIP}) \leq \frac{P(\text{ROS})}{P(\text{IIP})}$ ) or the limits for the probability of ROS given the occurrence of ESL are 0.83 and 1.00. When any of these probability estimates did not fit the proposed limits, the decision makers were asked to revise their initial estimation. Table 6 shows the occurrence matrix of internal opportunities for alternative A.

**Table 6. The Occurrence Matrix of Internal Opportunities for Alternative A**

| If This Factor Occurs | Initial Probability | The Probability of This Factor Becomes |      |      |      |      |
|-----------------------|---------------------|--|------|------|------|------|
|                       |                     | ROS                                    | IIP  | ESL  | COM  | ICS  |
| ROS                   | 0.90                | 0.95                                   | 0.75 | 0.65 | 0.35 | 0.85 |
| IIP                   | 0.70                | 0.95                                   | 0.75 | 0.75 | 0.50 | 0.90 |
| ESL                   | 0.60                | 0.85                                   | 0.85 | 0.55 | 0.55 | 0.80 |
| COM                   | 0.40                | 0.80                                   | 0.65 | 0.55 | 0.45 | 0.75 |
| ICS                   | 0.80                | 0.90                                   | 0.80 | 0.70 | 0.45 | 0.75 |

Next the nonoccurrence matrix is calculated. For example, the probability of ROS if IIP does not occur  $P(\text{ROS}/\bar{\text{IIP}}) = \frac{P(\text{ROS}) - P(\text{IIP})P(\text{ROS}/\text{IIP})}{1 - P(\text{IIP})}$  would be 0.78 or the probability of ROS if ESL does not occur would be 0.98. The entire matrix is calculated accordingly. Table 7 shows the nonoccurrence matrix of internal opportunities for alternative A.

**Table 7. The Nonoccurrence Matrix of Internal Opportunities for Alternative A**

| If This Factor Does Not Occur | Initial Probability | The Probability of This Factor Becomes |      |      |      |      |
|-------------------------------|---------------------|--|------|------|------|------|
|                               |                     | ROS                                    | IIP  | ESL  | COM  | ICS  |
| ROS                           | 0.90                |  | 0.25 | 0.15 | 0.85 | 0.35 |
| IIP                           | 0.70                | 0.78                                   |      | 0.25 | 0.17 | 0.57 |
| ESL                           | 0.60                | 0.98                                   | 0.48 |      | 0.18 | 0.80 |
| COM                           | 0.40                | 0.97                                   | 0.73 | 0.63 |      | 0.83 |
| ICS                           | 0.80                | 0.90                                   | 0.30 | 0.20 | 0.20 |      |

Next in order to perform the calibration run the odds ratios are calculated. Odds ratios are calculated by applying the following relationship to the initial and conditional occurrence and nonoccurrence probabilities given in Tables 6 and 7:

$$\text{Odds} = \frac{\text{probability}}{1 - \text{probability}}$$

The occurrence and nonoccurrence odds ratios of internal opportunities for alternative A is presented in Tables 8 and 9.

**Table 8. The Occurrence Odds Ratios of Internal Opportunities for Alternative A**

| If This Factor Occurs | Initial Odds | The Probability of This Factor Becomes |      |      |      |      |
|-----------------------|--------------|--|------|------|------|------|
|                       |              | ROS                                    | IIP  | ESL  | COM  | ICS  |
| ROS                   | 9.00         |  | 3.00 | 1.86 | 0.54 | 5.67 |
| IIP                   | 2.33         | 19.0                                   |      | 3.00 | 1.00 | 9.00 |
| ESL                   | 1.50         | 5.67                                   | 5.67 |      | 1.22 | 4.00 |
| COM                   | 0.67         | 4.00                                   | 1.86 | 1.22 |      | 3.00 |
| ICS                   | 4.00         | 9.00                                   | 4.00 | 2.33 | 0.82 |      |

**Table 9. The Nonoccurrence Odds Ratios of Internal Opportunities for Alternative A**

| If This Factor Does Not Occur | Initial Odds | The Probability of This Factor Becomes |      |      |      |      |
|-------------------------------|--------------|--|------|------|------|------|
|                               |              | ROS                                    | IIP  | ESL  | COM  | ICS  |
| ROS                           | 9.00         |  | 0.33 | 0.18 | 5.67 | 0.54 |
| IIP                           | 2.33         | 3.55                                   |      | 0.33 | 0.21 | 1.33 |
| ESL                           | 1.50         | 49.0                                   | 0.92 |      | 0.22 | 4.00 |
| COM                           | 0.67         | 32.3                                   | 2.70 | 1.70 |      | 4.88 |
| ICS                           | 4.00         | 9.00                                   | 0.43 | 0.25 | 0.25 |      |



Given this information and a computer-based simulation program, the calibration run of the matrix was made using the following procedure:

1. A factor is selected randomly.
2. A random number between 0.00 and 1.00 is generated. If the generated random number is less than the probability of the factor being tested, the factor is said to occur. Otherwise, the factor does not occur.
3. If the factor (factor 1) occurs, the odds of all other factors are adjusted as follows:

New odds of factor 2 = (Initial odds of factor 2)(Occurrence odds ratio of factor 1 and 2)

Given the above relationship new odds of all other factors are adjusted. If factor 1 does not occur, the same calculations are made using the nonoccurrence odds ratios.

4. All factors are tested for occurrence using steps 1 through 3.
5. Steps 1 through 4 are repeated a large number of times.
6. The frequency of occurrence of each factor for all runs represents the new calibration probability of that factor.

The results of this run for the internal opportunities and alternative A (given in Table 10) shows changes of no more than 0.04 for any factor.

**Table 10. Calibration Results of Internal Opportunities for Alternative A**

| Factor | Initial<br>Probability | Calibration<br>Probability | Change |
|--------|------------------------|----------------------------|--------|
| ROS    | 0.90                   | 0.93                       | +0.03  |
| IIP    | 0.70                   | 0.74                       | +0.04  |
| ESL    | 0.60                   | 0.58                       | -0.02  |
| COM    | 0.40                   | 0.41                       | +0.01  |
| ICS    | 0.80                   | 0.76                       | -0.04  |

This procedure is repeated for all probability sets. Table 11 shows the calibration probabilities for all opportunities and threats.

**Table 11. Calibrated Probabilities of Occurrence**

|                                  | ALTERNATIVES |      |      |      |      |
|----------------------------------|--------------|------|------|------|------|
|                                  | A            | B    | C    | D    | E    |
| <b>Internal Environment</b>      |              |      |      |      |      |
| ROS                              | 0.93         | 0.88 | 0.12 | 0.57 | 0.76 |
| IIP                              | 0.74         | 0.83 | 0.09 | 0.74 | 0.43 |
| ESL                              | 0.58         | 0.14 | 0.43 | 0.88 | 0.18 |
| COM                              | 0.41         | 0.77 | 0.56 | 0.75 | 0.36 |
| ICS                              | 0.76         | 0.84 | 0.27 | 0.96 | 0.41 |
| <b>Transactional Environment</b> |              |      |      |      |      |
| HQC                              | 0.84         | 0.91 | 0.11 | 0.75 | 0.85 |
| PHR                              | 0.42         | 0.23 | 0.72 | 0.83 | 0.76 |
| IMS                              | 0.18         | 0.29 | 0.54 | 0.68 | 0.28 |
| MCB                              | 0.23         | 0.07 | 0.12 | 0.78 | 0.50 |
| IOS                              | 0.20         | 0.14 | 0.07 | 0.64 | 0.78 |
| <b>Contextual Environment</b>    |              |      |      |      |      |
| RGC                              | 0.91         | 0.76 | 0.89 | 0.73 | 0.89 |
| GFA                              | 0.72         | 0.67 | 0.13 | 0.78 | 0.71 |
| AGL                              | 0.18         | 0.13 | 0.57 | 0.85 | 0.85 |
| <b>THREATS</b>                   |              |      |      |      |      |
| <b>Internal Environment</b>      |              |      |      |      |      |
| RTC                              | 0.42         | 0.63 | 0.43 | 0.74 | 0.53 |
| IEX                              | 0.21         | 0.12 | 0.56 | 0.83 | 0.86 |
| RDE                              | 0.84         | 0.86 | 0.15 | 0.32 | 0.14 |
| LAS                              | 0.08         | 0.91 | 0.77 | 0.18 | 0.27 |
| <b>Transactional Environment</b> |              |      |      |      |      |
| NPH                              | 0.14         | 0.33 | 0.43 | 0.43 | 0.06 |
| RIS                              | 0.21         | 0.38 | 0.90 | 0.17 | 0.11 |
| SAD                              | 0.09         | 0.13 | 0.12 | 0.22 | 0.14 |
| CSU                              | 0.16         | 0.26 | 0.08 | 0.38 | 0.09 |
| ILC                              | 0.11         | 0.07 | 0.11 | 0.31 | 0.42 |
| <b>Contextual Environment</b>    |              |      |      |      |      |
| TMC                              | 0.12         | 0.13 | 0.34 | 0.23 | 0.85 |
| RIP                              | 0.21         | 0.11 | 0.14 | 0.28 | 0.46 |
| RGR                              | 0.07         | 0.08 | 0.06 | 0.42 | 0.79 |

Next, we calculate the overall importance weight for opportunities and threats given the original subjective weights and the intrinsic information provided by the newly calibrated probabilities. Let us use the opportunity factors in the internal environment. 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  $\hat{p}_{u_{ij}}^m$ 's representing the calibration probability of occurrence of five alternatives on five opportunity factors in the internal environment. First we calculate  $e(\hat{p}_{u_{ij}}^m)$ , the entropy measure of the  $j$ -th opportunity factor. Table 12 contains the information necessary to calculate  $e(\hat{p}_{u_{ij}}^m)$ .

**Table 12. Information Necessary for Calculating  $e(\hat{p}_{u_{ij}}^m)$**

| Factor | $\hat{p}_{u_{ij}}^m$ |      |      |      |      | $\hat{P}_{ij}$ | $\hat{p}_{u_{ij}}^m / \hat{P}_{ij}$ |       |       |       |       |
|--------|----------------------|------|------|------|------|----------------|-------------------------------------|-------|-------|-------|-------|
|        | A                    | B    | C    | D    | E    |                | A                                   | B     | C     | D     | E     |
| ROS    | 0.93                 | 0.88 | 0.12 | 0.57 | 0.76 | 3.26           | 0.285                               | 0.270 | 0.037 | 0.175 | 0.233 |
| IIP    | 0.74                 | 0.83 | 0.09 | 0.74 | 0.43 | 2.83           | 0.261                               | 0.293 | 0.032 | 0.262 | 0.152 |
| ESL    | 0.58                 | 0.14 | 0.43 | 0.88 | 0.18 | 2.21           | 0.263                               | 0.063 | 0.195 | 0.398 | 0.082 |
| COM    | 0.41                 | 0.77 | 0.56 | 0.75 | 0.36 | 2.85           | 0.144                               | 0.270 | 0.197 | 0.263 | 0.126 |
| ICS    | 0.76                 | 0.84 | 0.27 | 0.96 | 0.41 | 3.24           | 0.235                               | 0.259 | 0.083 | 0.269 | 0.127 |

We know that  $e_{max} = \ln 5 = 1.6094$ , and we set  $K = 1/e_{max} = 0.6213$ . For  $j = 1$  we obtain:

$$e(\hat{p}_{u_{11}}) = - (0.6213)[0.285(\ln 0.285) + 0.270 (\ln 0.270) + 0.037 (\ln 0.037) + 0.175 (\ln 0.175) + 0.233 (\ln 0.233)]$$

In summary, we calculate:

$$e(\hat{p}_{u_{11}}) = 0.918 \quad e(\hat{p}_{u_{12}}) = 0.905 \quad e(\hat{p}_{u_{13}}) = 0.879 \quad e(\hat{p}_{u_{14}}) = 0.972 \quad e(\hat{p}_{u_{15}}) = 0.944$$

and  $E$ , the sum of all  $e(p_{u_{ij}})$  is 3.328. Substituting in the formula for  $F_{u_{ij}}$  the intrinsic weight, we obtain:

$$F_{u_{11}} = 0.216 \quad F_{u_{12}} = 0.248 \quad F_{u_{13}} = 0.317 \quad F_{u_{14}} = 0.073 \quad F_{u_{15}} = 0.147$$

The subjective weights had already been estimated by the decision maker as:

$$w_{u_{11}} = 0.484 \quad w_{u_{12}} = 0.262 \quad w_{u_{13}} = 0.131 \quad w_{u_{14}} = 0.077 \quad w_{u_{15}} = 0.046$$

Comparing  $W_{u_{ij}}$ 's and  $F_{u_{ij}}$ 's, we see that the large  $w_{u_{11}}$  will be offset by relatively small  $F_{u_{11}}$  and the small  $w_{u_{14}}$  will be offset by the large  $F_{u_{14}}$ . Substituting them in the formula for  $F_{u_{ij}}$ , the overall importance weight, we obtain:

$$\hat{F}_{u_{11}} = 0.455 \quad \hat{F}_{u_{12}} = 0.284 \quad \hat{F}_{u_{13}} = 0.181 \quad \hat{F}_{u_{14}} = 0.030$$

Next we measure the decision maker's risk-aversion constant for opportunities and threats using the Gain Equivalence (GE) method. For example, let's assume that the decision maker is indifferent between (1) getting \$0 for sure and (2) playing a lottery with a 50% probability of winning \$5000 and 50% probability of losing \$2500. The risk aversion constant towards this factor would be the reciprocal of the \$5000 that gives the indifference ( $1/5000 = 0.0002$ ). This procedure is repeated until the risk aversion constant for all opportunities and threats are determined. These risk-aversion constants along with the overall weights of each factor, calibration probabilities, and the risk-adjusted strategic value for each of the five alternatives are listed as a part of Table 13.

As it is shown in Table 13, alternative A has the highest risk-adjusted strategic value (0.446) followed by alternative D (0.303). Alternatives B and E yielded risk-adjusted strategic values of 0.279 and 0.208 while alternative C yielded a negative risk-adjusted strategic value of -0.311. Based on these calculations the most attractive alternative is A.

Table 13. Summarized Comparison Between Strategic Alternatives

| Factor                                 | Env. Weight | Overall Weight | Risk Aversion | ALTERNATIVES |              |               |              |              |
|--|-------------|----------------|---------------|--------------|--------------|---------------|--------------|--------------|
|  |             |                |               | A            | B            | C             | D            | E            |
| ROS                                    | 0.637       | 0.455          | 0.8000        | 0.93         | 0.88         | 0.12          | 0.57         | 0.76         |
| IIP                                    |             | 0.284          | 0.7000        | 0.74         | 0.83         | 0.09          | 0.74         | 0.43         |
| ESL                                    |             | 0.181          | 0.0040        | 0.58         | 0.14         | 0.43          | 0.88         | 0.18         |
| COM                                    |             | 0.030          | 0.0010        | 0.41         | 0.77         | 0.56          | 0.75         | 0.36         |
| ICS                                    |             | 0.030          | 0.0900        | 0.76         | 0.84         | 0.27          | 0.96         | 0.41         |
| HQC                                    | 0.258       | 0.444          | 0.6000        | 0.84         | 0.91         | 0.11          | 0.75         | 0.85         |
| PHR                                    |             | 0.182          | 0.0700        | 0.42         | 0.23         | 0.72          | 0.83         | 0.76         |
| IMS                                    |             | 0.116          | 0.9000        | 0.18         | 0.29         | 0.54          | 0.68         | 0.28         |
| MCB                                    |             | 0.099          | 0.8000        | 0.23         | 0.07         | 0.12          | 0.78         | 0.50         |
| IOS                                    |             | 0.099          | 0.0600        | 0.20         | 0.14         | 0.07          | 0.64         | 0.78         |
| RGC                                    | 0.105       | 0.081          | 0.0020        | 0.91         | 0.76         | 0.89          | 0.73         | 0.89         |
| GFA                                    |             | 0.399          | 0.0500        | 0.72         | 0.67         | 0.13          | 0.78         | 0.71         |
| AGL                                    |             | 0.520          | 0.0080        | 0.18         | 0.13         | 0.57          | 0.85         | 0.85         |
| <i>Risk-adjusted Opportunity Value</i> |             |                |               | <b>0.640</b> | <b>0.591</b> | <b>0.206</b>  | <b>0.645</b> | <b>0.542</b> |
| THREATS                                |             |                |               |              |              |               |              |              |
| RTC                                    | 0.079       | 0.121          | 0.0001        | 0.42         | 0.63         | 0.43          | 0.74         | 0.53         |
| IEX                                    |             | 0.450          | 0.0030        | 0.21         | 0.12         | 0.56          | 0.83         | 0.86         |
| RDE                                    |             | 0.273          | 0.0070        | 0.84         | 0.86         | 0.15          | 0.32         | 0.14         |
| LAS                                    |             | 0.156          | 0.0800        | 0.08         | 0.91         | 0.77          | 0.18         | 0.27         |
| NPH                                    | 0.659       | 0.385          | 0.8000        | 0.14         | 0.33         | 0.43          | 0.43         | 0.06         |
| RIS                                    |             | 0.442          | 0.0900        | 0.21         | 0.38         | 0.90          | 0.17         | 0.11         |
| SAD                                    |             | 0.033          | 0.1000        | 0.09         | 0.13         | 0.12          | 0.22         | 0.14         |
| CSU                                    |             | 0.050          | 0.7000        | 0.16         | 0.26         | 0.08          | 0.38         | 0.09         |
| ILC                                    |             | 0.050          | 0.8000        | 0.11         | 0.07         | 0.11          | 0.31         | 0.42         |
| TMC                                    | 0.262       | 0.682          | 0.0400        | 0.12         | 0.13         | 0.34          | 0.23         | 0.85         |
| RIP                                    |             | 0.126          | 0.6000        | 0.21         | 0.11         | 0.14          | 0.28         | 0.46         |
| RGR                                    |             | 0.192          | 0.5000        | 0.07         | 0.08         | 0.06          | 0.42         | 0.79         |
| <i>Risk-adjusted Threat Value</i>      |             |                |               | <b>0.194</b> | <b>0.312</b> | <b>0.517</b>  | <b>0.342</b> | <b>0.344</b> |
| <i>Risk-adjusted Strategic Value</i>   |             |                |               | <b>0.446</b> | <b>0.279</b> | <b>-0.311</b> | <b>0.303</b> | <b>0.208</b> |

## APPENDIX

To formulate an algebraic model used in this case study, 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)
- $\hat{p}_{u_{ij}}^m$  = The m-th Calibration 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)
- $\hat{p}_{t_{ij}}^m$  = The m-th Calibration 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)
- $N_{t_i}$  = Number of Threat Factors in the i-th Environment (i = 1, 2, and 3)

Assuming that i = 1 through 3 represent the internal, transactional and contextual environments, respectively, we find the most attractive risk-adjusted strategic value for the m-th strategic alternative as:

$$V^m = U^m + T^m \quad (10)$$

where

$$U^m = \sum_{i=1}^3 W_{u_i} \left\{ \sum_{j=1}^{N_{u_i}} \hat{F}_{u_{ij}} \left[ -\frac{1}{r_{u_{ij}}} \ln (1 - \hat{p}_{u_{ij}}^m + \hat{p}_{u_{ij}}^m e^{-r_{u_{ij}}}) \right] \right\} \quad (11)$$

$$T^m = \sum_{i=1}^3 W_{t_i} \left\{ \sum_{j=1}^{N_{t_i}} \hat{F}_{t_{ij}} \left[ -\frac{1}{r_{t_{ij}}} \ln (1 - \hat{p}_{t_{ij}}^m + \hat{p}_{t_{ij}}^m e^{r_{t_{ij}}}) \right] \right\} \quad (12)$$

and

$r_{u_{ij}}$  = The decision maker's risk-aversion constant for the j-th opportunity factor in the i-th environment.

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

We assume  $r$ , the decision maker's risk-aversion constant to be greater than zero, representing aversion toward risk. We do 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 [26]. In addition let us assume:

$$\sum_{i=1}^3 W_{u_i} = 1 \quad (13)$$

$$\sum_{i=1}^3 W_{t_i} = 1 \quad (14)$$

$$\sum_{j=1}^{N_{u_i}} \hat{F}_{u_{ij}} = 1 \quad (15)$$

$$\sum_{j=1}^{N_{t_i}} \hat{F}_{t_{ij}} = 1 \quad (16)$$

$$0 \leq \hat{p}_{u_{ij}}^m \leq 1 \quad (17)$$

$$0 \leq \hat{p}_{t_{ij}}^n \leq 1 \quad (18)$$