

# Putting the Structure in

By William B. Lee and Errol Wirasinghe

Many supply chain managers make the critical error of equating making decisions with solving problems. Decision making is not problem solving. Decision making is specific to the person. Problem solving is specific to the problem. Our work suggests that problem solvers are not necessarily the best decision-makers, and perhaps vice versa.

We have all heard jokes like, “to a surgeon, cutting can fix anything” or “to a chiropractor, manipulation can fix anything” or “to a psychologist, everything’s mental.” These jokes are, of course, not fair to those professionals, particularly the good ones. But don’t we have the same sort of phenomenon with our supply chain decision making? Some will advocate that “lean can fix everything” or that “everyone needs to do Six Sigma.” Again, we don’t want to criticize the advocates of those techniques, just as we don’t want to disparage surgeons or chiropractors or psychologists. It’s just that we need to take a longer, more analytical look at our supply chain decisions and not simply jump in with the latest buzz word. We believe one of the reasons companies have so much trouble with their supply chains is a lack of a structured decision-making process.

Many surveys have shown that an overwhelming majority of professionals indicate that they rely on “common-sense and gut-feel” interpretation of data and subsequent decision making. They are inconsistent in how they approach decisions,

and yet they frequently institute rules in an attempt to be more consistent. They also systematically distort certain pieces or types of information. The result of these decision-making approaches typically is that the same situation presented repetitively yields different decisions. Furthermore, these decisions rarely are anywhere close to being optimal.

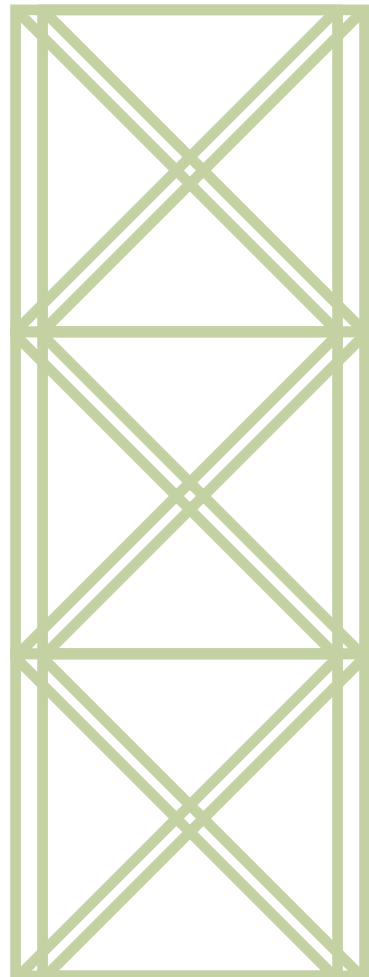
This is pretty sad. Clearly, we are not going to do much to fix this situation with this one article, but maybe we can help. Many good books have been written on decision making; Two of the best are David C. Skinner’s *Introduction to Decision Analysis*<sup>1</sup> and Errol Wirasinghe’s *The Art of Making Decisions*.<sup>2</sup> Our objective is instead to highlight the role of decision-making processes, analysis, and models in supply chains.

Specifically, we offer seven steps to a more structured approach to supply chain decision-making:

1. Frame and describe the situation about which a decision is to be made.
2. Define the objective(s) of the decision and the criteria that define the objectives.
3. Extract obligatory criteria.
4. Creatively identify decision options that meet all obligatory criteria.
5. Gather information on decision alternatives, and develop the judgment table.
6. Assign weights to the obligatory criteria.
7. Rank alternatives.

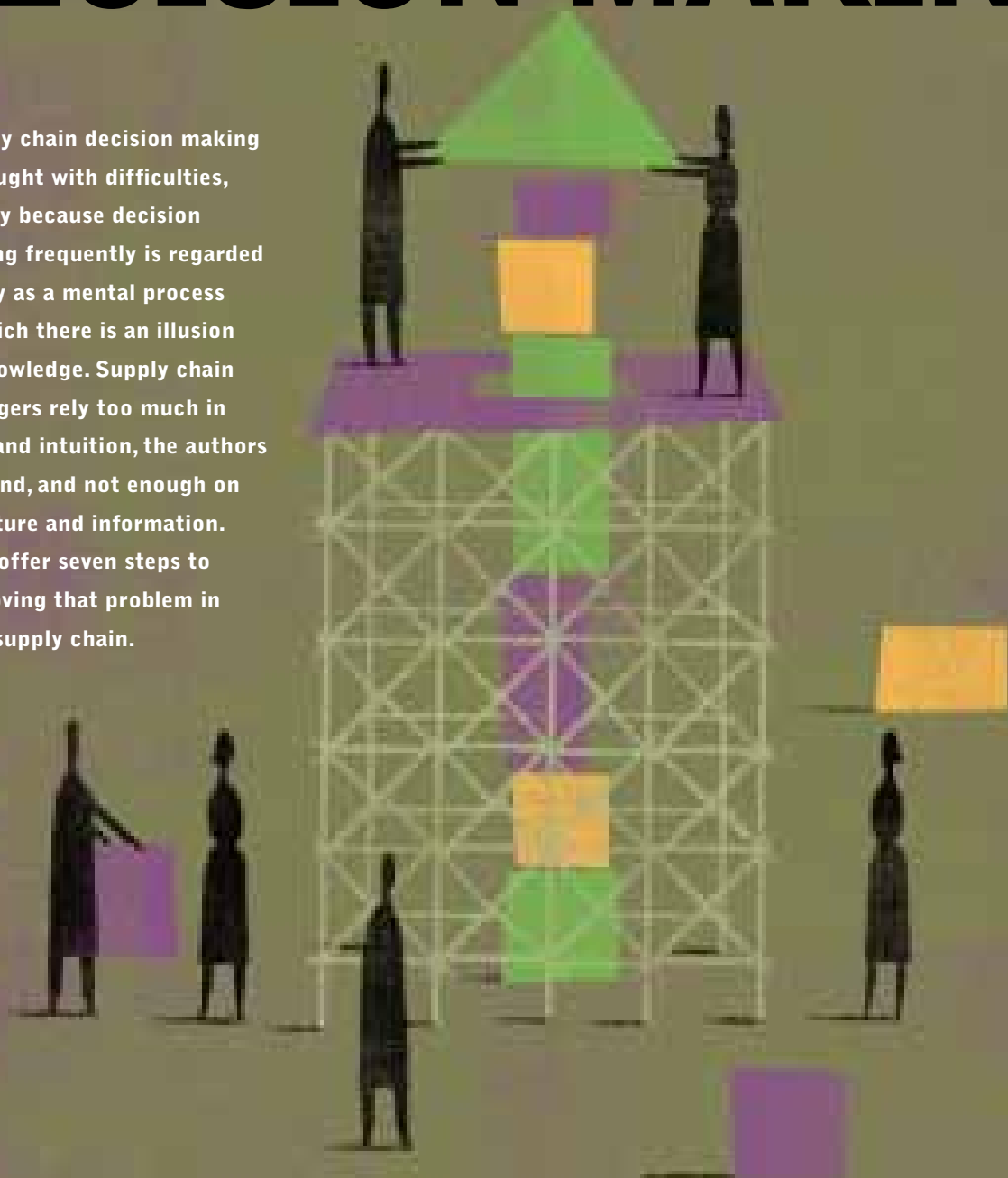
To illustrate the use of such models, we like the old quote: “All models

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# DECISION MAKING

Supply chain decision making is fraught with difficulties, largely because decision making frequently is regarded purely as a mental process in which there is an illusion of knowledge. Supply chain managers rely too much in guts and intuition, the authors contend, and not enough on structure and information. They offer seven steps to improving that problem in your supply chain.



are wrong, some models are useful.”

What are the implications of this quote—especially in this context of supply chain decision making? There are many, and we will explore some of them in the discussion that follows.

### Complexity Drives Decision-Making

Readers of *SCMR* likely will agree that most supply chains are complex, particularly as they extend past suppliers to suppliers’ suppliers, and past customers to customers’ customers. Most companies also have multiple supply chains, which add additional complexity. In many industries, supply chain management perhaps is the single most important driver of the company’s success and

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the single most difficult area of decision making.

Complexity drives uncertainty and risky environments for the decision maker. Uncertainty of demand and supply, uncertainty of the global business environment and many other uncertainties are prevalent. Risk of product failures, of customers or suppliers going out of business, of financial meltdowns—and many other risks also are widespread. Decision makers need to deal with all of these issues.

Importantly, please also recognize that relying on financial data alone can lead us to sub-optimal decisions. The message here is that we need a robust technique for handling multi-criteria decision making, and for validating decisions. A robust technique is one that is straightforward and that is difficult to misuse to get the wrong answer. The “guts and intuition” approach to decision making, by contrast, can easily lead a person or an organization astray.

The theory and practice of decision making (or “decision theory”) classifies decisions as follows: decision making under certainty (DMUC), decision making under uncertainty (DMUU), and decision making under risk (DMUR). Decision theory contains well-known approaches to each.

When we know for certain the outcome associated with each decision alternative, it’s called *decision making under certainty*. Some, but not many, supply chain decisions fall into this category—mostly short-term decisions. Of course, how certain is certain? No decision

outcome is really certain, as we say, down to the 47th decimal place! Scheduling decisions, for example, sometimes might be considered relatively certain. When you place an order with Dell, they promise delivery of a computer in a certain number of days after your order, and it’s there right on schedule with very little variation from one customer to another. Dell has made their mastery of the supply chain a real competitive advantage in the marketplace. FedEx is another example of a company that can promise delivery with some degree of certainty.

When a decision alternative can result in more than one possible outcome, along with an uncertain probability of occurrence, then we call it *decision making under uncertainty*. However, when we know the probability of each possible outcome, we call it *decision making under risk*. But, you argue, isn’t our knowledge of the probabilities really just a guess and really a continuum? In most cases, that is true.

Consider a simple example.

Say, we have a supply chain decision about a possible new supplier with two possible outcomes: “successful choice” or “unsuccessful choice”. If we really do not know the true probabilities for either, we may choose to assign a 50/50 likelihood. But this really is a “perception-driven interpretation.” Maybe it’s 60/40 or 40/60. Or, maybe it’s a normal distribution with a mean of 50 percent and a standard deviation of 10 percent? We have just turned DMUU into DUMR or, perhaps, into a continuum DMUR.

### Case Study: Decisions Under Risk

In supply chain decision making, DMUR likely is the most prevalent condition. Let’s look at a real case of a large lubricants company. We have disguised the case for use in our MBA and executive education teaching. Further, for this article we obviously have simplified the details of the case while nevertheless retaining the essence of the decision problem.

One of the company’s specialty lubricants plants is experiencing a substantial increase in business. Feedstock supply is not an issue. The plant is an essential element of the company’s supply chain as well as of its customers’. The company is considering three courses of action:

- A. Subcontract for additional capacity
- B. Construct new plant
- C. Do nothing (no change)

Demand may be low, medium, or high with probabilities estimated to be 10 percent, 50 percent, and 40 per-

cent respectively.

The company first is interested in the financial impact of the decision. It can estimate the net present value of profits from the three alternatives (A, B, and C) under the differing levels of demand. This is the “Payoff Matrix” shown in Exhibit 1. Several criteria can be used to make the decision regarding which of the three alter-

**EXHIBIT 1**

**Payoff Matrix**

Demand	Low Demand	Medium Demand	High Demand
Probabilities of Demand	10%	50%	40%
Decision Alternatives	Net Percent Value of Profits from the Decision		
A. Subcontract of Additional Capacity	\$10m	\$50m	\$90m
B. Construct New Plant	-\$120m	\$25m	“Maximax” \$200m
C. Do Nothing (No Change)	“Maximin” \$20m	\$40m	\$60m

natives to choose.

**The Maximin Criterion.** Maximin is a criterion of extreme pessimism. It attempts to maximize the minimum possible gain. This is done by determining the smallest possible gain for each alternative if the worst

**EXHIBIT 2**

**“Regret” Matrix**

Demand	Low Demand	Medium Demand	High Demand
Decision Alternatives	Net Present Value of “Regret” from Decisions		
A. Subcontract of Additional Capacity	\$10m	\$0m	“Minimax Regret” \$110m
B. Construct New Plant	\$140m	\$25m	\$0m
C. Do Nothing (No Change)	\$20m	\$10m	\$140m

possible event occurs. The alternative is selected that has the best outcome under the poorest conditions—the maximum of the minimums. Under this criterion, the best choice is C with a return of \$20 million. The minimum for A is \$10 million, and for B it is minus-\$120 million.

**The Maximax Criterion.** This is the criterion of extreme optimism. Its objective is to select the decision alternative that will provide the maximum possible return, regardless of the associated probabilities. Under this criterion, the best choice is B with a maximum return of \$200 million—the maximum of the maximums. The maximum for A is \$90 million, and for C it is \$60 million.

**The Minimax Regret Criterion.**

“Regret” is synonymous with the opportunity cost of not having made the best decision for a given outcome. It follows that the decision maker would like to make a decision that minimizes regret. This is the “Regret Matrix” shown in Exhibit 2. Say, “high” demand occurs, and the payoff from decision A would have been \$90 million, the payoff from decision B would have been \$200 million, and the payoff from decision C would have been \$60 million. The “regret” from A would have been \$110 million (\$200 million minus \$90 million). This is the “minimax regret” (the minimum of the maximum regrets) choice.

**The Expected Value Criterion.** This criterion weights the outcomes by their probability of occurring. For example, using the payoffs and probabilities cited above, the expected value for decision A is \$62 million ( $\$90 \text{ million} \times 0.4 + \$50 \text{ million} \times 0.5 + \$10 \text{ million} \times 0.1$ ). This is shown in the “Expected Value” Matrix in Exhibit 3. The maximum expected value is \$80.5 million, decision B.

We often ask questions such as the following. “Given the information as presented, what would you do with the lubes plant decision and why? Especially since all three alternatives were chosen under different decision criteria.” And what about the model? In what ways is the model an abstraction from reality, and what difference does it make? What additional information would you want if this were your decision?”

There are many ways we can make this model more complex and thus more “realistic.” One example is sensitivity—we could test the sensitivity of the decision to the probability estimates, to the payoff estimates, and even to the decision alternatives themselves. Another example of additional complexity is with Alternative B: “What size of a new plant should we construct—small, medium, large, or very large?” Any number of additional complexities could be added to the decision.

**EXHIBIT 3**

**“Expected Value” Matrix**

	Expected Value
A. Subcontract of Additional Capacity	\$62m
B. Construct New Plant	Maximum Expected Value = \$80.5m
C. Do Nothing (No Change)	\$46m

So, what has this revealed? We have used this simplified (but realistic) example of a supply chain decision with three choices. By applying some very commonsense financial decision rules, all three choices have been shown to be reasonable under different decision criteria.

What's a supply chain manager to do? To try to put some light on this subject, let's look into some key supply chain decisions that need to be made and a structured approach for making them.

### Key Supply Chain Decisions

It is useful to consider ways to classify supply chain decisions so that we can apply decision-making processes appropriately. One of the most effective classifications was presented by David Simchi-Levi and his co-authors

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in *Designing and Managing the Supply Chain*.<sup>3</sup> The following is adapted from that work:

1. *Strategic decisions* have a long-lasting (one to ten years typically) effect on the organization. These include target customers and their characteristics, product and service selection and design, distribution network configurations such as numbers and locations of facilities, structure and processes of the supply chain, supplier relationships, and so forth. Since these decisions are both long lasting and typically of great consequence, more time, effort, and formality usually are taken in the decision process. The lubricants plant above is an example of a strategic decision.

2. *Tactical decisions* include decisions that typically can be updated anywhere between quarterly and yearly. These likely include purchasing and supply contracts, production decisions, inventory policies, sales and operations planning, and so forth. These decisions are important but reversible in the intermediate time period. Thus, they would deserve some intermediate level of formality in the decision making process.

3. *Operational decisions* refer to day-to-day decisions such as scheduling, quotations, transportation, and so forth. These decisions typically last only a short period of time and are of little consequence if wrong. Thus, people likely will spend relatively little time or resources in making them individually. However, management frequently develops decision rules that apply to an entire

class (say, quotations) of these decisions. For example, quotation decision rules may be something like “take the product standard cost and add a 40 percent markup for the price.”

Structured decision processes, the focus of our discussion, usually deal with strategic and tactical decisions.

### The Structured Approach

Many of us are accustomed to making decisions on the basis of quantitative data. The rate of return on a project, or the expected demand for a product, are easily explained in terms of numbers. In the above example, we developed a payoff matrix and applied financial criteria to the decision. But this is just one criterion. In the real world, there are many factors at play; these are what we refer to as “criteria.”

Inherent in many supply chain decisions are factors such as company strategy, competition, customers, suppliers, bureaucracy, language barriers, governmental issues, and so forth—all of which are

qualitative in nature. Thus the subjective human being (the decision maker) adds inevitable biases when he or she includes certain criteria, and excludes others.

To most people, a good decision is one that produces the desired outcome. Unfortunately this is a very limited definition. David Skinner makes a good point about outcomes and the relative desirability of possible outcomes.<sup>1</sup>

“Outcomes are what can happen. As an example, if you were going to have heart surgery, the outcomes could be:

- complete recovery, no side effects,
- partial recovery, some side effects, or
- death.”

Clearly, we all would have our preferences about the outcome! So part of having a robust decision making process is a strong linkage of the decision(s)—say, not only whether to have heart surgery, but whom to choose as the surgeon, where to have the surgery, and the surgeon's decisions before, during, and after surgery—to the possible outcomes. We all know that different surgeons and different hospitals have different outcome probabilities. We want to weigh these in our decision process.

The quality of the decision will depend on a number of things: the decision alternatives, decision criteria, available data and information, context and domain of the decision, analysis techniques used, the expertise of the decision maker, and so forth. However, the outcome of the decision will, additionally, depend on appropriate timing, adequate resources, commitment to execution,

and changing circumstances, among other factors.

As an alternative to gut-feel and pure common-sense techniques, we offer a seven-step process to making solid, structured decisions. We will discuss the steps in terms of the previous example. This approach is invaluable when we deal with qualitative information and criteria.

### **1. Frame and describe the situation about which a decision is to be made.**

We paraphrase a famous anonymous quote: “A decision well framed is half made.” The first step is to define the decision in light of the company’s strategy, along with the decision’s boundaries, interfaces, and influences. Strategic thinking drives decision making by:

- Setting strategic direction for the business.
- Establishing the objectives to deliver results.
- Creating measures to track progress toward objectives.
- Specifying behaviors that are required to implement the strategy.

Each of these is important as we frame our supply chain decisions.

### **2. Define the objective(s) of the decision and the criteria that define the objectives.**

Objectives must be stated in unambiguous terms. Additionally, they should be time-bound, and progress must be measurable. In the earlier lubes plant example, we may have an objective stated as: “Determine the best option to meet the expected demand growth for the next five years.” Wherever possible it is essential to have a statement (such as this one) that would allow us to measure progress in terms of achieving this objective. Thus, if the expected progress is not being achieved, we can take corrective measures in a timely manner.

Criteria explicitly define the objectives of the decision. As we structured the problem previously, the payoff matrix is just one criterion—financial. Most supply chain decisions (and most others for that matter) are multiple-criteria decisions—meaning that there are multiple objectives which the decision needs to achieve. The financial payoff matrix indicated no clear preferred option, but we would have needed to consider other criteria anyway. These could be, for example, the following four additional criteria.

- *Strategic fit.* How well do the candidate decision alternatives fit with the company’s strategic direction? Does the company prefer outsourcing or not outsourcing? Does the company prefer to own excess capacity or to be tight on capacity?
- *Management capability.* Does the company have the necessary management capability to implement the

options? If outsourcing is unfamiliar to the management team, this may be a difficult alternative to implement.

- *Risk.* Do the options present unacceptable risk to the company—defined in whatever way the company deems useful? For example, part of a robust decision process likely should be the possible environmental risk.
- *Customers’ needs.* How well do the alternatives fit the needs of the customers?

### **3. Extract obligatory criteria.**

With criteria, more is not merrier. As we add more criteria, the significance of the existing criteria is diluted. More than about 10 criterion require some sort of prioritization to extract the obligatory criteria simply because we may not be able to deal effectively with that many choices. The remaining criteria may be desirable or nice-to-have but not necessary. If there is a tie between the top two candidates, then we may revert to these desirable criteria to make a final decision.

The Analytic Hierarchy Process<sup>4</sup> (AHP) is a structured pair-wise comparison technique for dealing with complex decisions. Rather than prescribing a “correct” decision, the AHP helps the decision makers find the one that best suits their needs and their understanding of the problem. Several firms supply computer software to assist in using the process. AHP is beyond the scope of this article, but we wanted to introduce the idea and suggest that our readers go beyond the present discussion in this important area.

### **4. Creatively identify decision options that meet all obligatory criteria.**

We have already identified the decision alternatives: sub-contract, build a new plant, or do nothing. Although we noted that each of these could be expanded into numerous sub-options such as build a small plant, or a medium-size one, or a large one, or on and on. We thus could build a hierarchy of decision options. Such a hierarchy can be analyzed using AHP. As to the “creative” approach, Errol Wirasinghe, in his book, says it well:

“The role of creativity is that of generating and identifying options with which to solve a problem. ... Creativity consists largely of rearranging what we know in order to find out what we do not know. A pile of rocks ceases to be a rock pile when someone contemplates it as a cathedral.”<sup>2</sup>

### **5. Gather information on decision alternatives, and develop the judgment table.**

This is where we note the pros and cons pertaining to the criteria, for each of our candidates. The quality of

our final decision will depend on how much effort we dedicate to the task. Do not skip this step; without adequate information about the candidates, we cannot make a reliable decision.

### 6. Assign weights to the obligatory criteria.

All criteria do not have the same significance. We may run an AHP evaluation to assign criteria weights. There is a danger in using common sense because you may become a victim of “hidden traps” in decision making as outlined in a 2006 *Harvard Business Review* article on the subject that we highly recommend.<sup>5</sup> The article

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mentions several types of traps, but postulates that what makes all of them so dangerous is their invisibility. Because they are hardwired into our thinking process, and thus our common sense, we fail to recognize them—even as we fall right into them.

### 7. Rank alternatives.

Ranking alternatives typically begins by discarding those that appear obviously inferior. In the lubes example, we intentionally did not include any inferior alternatives. Then, we run a pair-wise analysis on the decision alternatives using our judgment table. The decision maker systematically evaluates the various alternatives by comparing them to one another two at a time. That is, we compare subcontracting with building, subcontracting with doing nothing, and building with doing nothing. In making the comparisons, the decision makers can use concrete data, or they can use their judgments about the options’ relative meaning and importance.

To validate the decision, we described the decision situation, decided which criteria are relevant; and assigned weights to these criteria to reflect their significance. At this point, we need to ask, Did our “human feelings” overly bias the decision in favor of some alternative? These may be some of the decision traps mentioned above.

Another very relevant validating question is: Will the winning candidate be valid if we were to remove any particular criterion? We then remove one criterion at a

time and see its impact on the decision. Clearly, if we remove any single criterion, then we must re-evaluate the weightings of the remaining ones.

### Next Steps

The reader should be aware of one caveat—we cannot possibly cover the subject of supply chain decision making in one short article such as this. Countless articles and books have been written on the subject of decision making alone, without adding the difficulties of supply chains. We thus have chosen to take a very narrow slice and not try to deal with such a complex subject in anything near a complete manner.

Our objective here has been to encourage the readers to consider how to structure decisions so as to improve their decision-making process. We have examined the dynamics of the decision process—the “how” and “why” of decision making—and have explained some elements of the structuring process. We also have shown how one approach (the financial one) easily can provide conflicting results and why most decision situations are multi-dimensional.

The example of the lubes plant shows a common structure of the financial role in the decision process—we can say (tongue firmly placed in cheek), “you tell me the answer you want, and I’ll tell you what criterion to use!” We could expand this little statement to say that we also can manipulate the payoff matrix to give you the answer you want. But, that’s not fair is it?

So, our message is to be careful about how you define the decision under consideration. We feel making use of the seven steps described here is the best way of helping to ensure a robust decision-making process. ☺☺

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### End Notes

- 1 Skinner, David C., *Introduction to Decision Analysis: A Practitioner’s Guide to Improving Decision Quality*, Second Edition, Probabilistic Publishing, 1999.
- 2 Wirasinghe, Errol, *The Art of Making Decisions: Expanding Common Sense & Experience*, Shanmar Publishing, 2003.
- 3 Simchi-Levi, David, Philip Kaminsky, and Edith Simchi-Levi, *Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies*. McGraw-Hill Irwin, 2008.
- 4 See Wikipedia article on “Analytic Hierarchy Process” for an introductory explanation and other references. (Accessed February 2010).
- 5 Hammond, John S., Ralph L. Keeney, and Howard Raiffa, “The Hidden Traps in Decision Making,” *Harvard Business Review*, January 2006.