USING LOGICAL TECHNIQUES FOR MAKING BETTER DECISIONS

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Using Logical Techniques for Making Better Decisions

Foreword

For sixty years the *Harvard Business Review* has been the farthest reaching executive program of the Harvard Business School. It is devoted to the continuing education of executives and aspiring managers primarily in business organizations, but also in not-for-profit institutions, in government, and in the professions. Through its publishing partners, reprints, and translation programs, it finds an audience in many languages in most countries in the world, occasionally even penetrating the barrier between East and West.

The *Harvard Business Review* draws on the talents of the most creative people in modern business and in management education. About half its content comes from practicing managers, the rest from professional people and university researchers. Everything *HBR* publishes has something to do with the skills, attitudes, and knowledge essential to the competent and ethical practice of management.

This book consists of thirty-two articles showing managers how to use quantitative techniques to make qualitative decisions. Neither abstruse nor superficial, the articles chosen for this volume are intended to be usefully analytical, challenging, and carefully prescriptive. Every well-informed businessperson can follow the exposition in its path away from the obvious and into the territory of independent thought. I hope that readers can adapt these ideas to their own unique situations and thus make their professional careers more productive.

KENNETH R. ANDREWS, Editor
Harvard Business Review

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Introduction

DOUGLAS N. DICKSON

No one will dispute the fact that a manager's toughest job is making the right decisions. Whether concerned with budgeting, investing, or product development, these choices have a wider and more uncertain impact than any the manager faces in personal life. For that reason, of course, managers spend a great deal of time trying to find new ways to make the best decisions.

Of all the things managers can call on today to make this nagging part of their business lives easier—and more profitable—perhaps none is more discussed, yet used with less frequency, than the range of mathematical tools, known in some circles as quantitative decision making techniques or "managerial economics." At its heart, the idea of applied mathematics is to quantify reality so as to better understand it. In the same way, these quantitative techniques are geared to help managers quantify their perceptions of reality (as well as the facts that they do know) in order to more readily handle the uncertainty of decision making.

While the application of mathematics to business dates back to the origins of business "science" in the early twentieth century, the use of statistics to keep track of inventories by the Navy in World War II provided a springboard to wider dissemination of the usefulness of the ideas. What made the promise of mathematical help brighter—at least initially—was the development of computers (beginning with Univac). Computers made the calculation of solutions to mathematical formulas more widely accessible. Now the techniques range in sophistication from regression analysis to decision analysis to simulation, econometric models, and multivariate analysis.

Despite this proliferation of techniques and their applicability to a widening range of complex problems—as well as the increased understanding, availability, and simplicity of computers—most managers have not progressed beyond the simplest mathematics in their work. Frankly, they do not understand or use sophisticated quantitative tools to any great extent. And when they do, it is always with a skeptical eye that makes the total process unsatisfying and generally unrewarding.

The best evidence of the bedrock nature of this reluctance—and the failure of quantitative techniques to catch on in terms of practical use—comes in two *Harvard Business Review* articles, more than ten years apart. In the first, "Do Managers Find Decision Theory Useful?" Rex Brown admitted that the use of quantitative techniques was not yet widespread, but that managers would come to use them in the coming decade. In the second, "Decision Analysis Comes of Age," however, Rex Brown (this time writing with Jacob Ulvila) relates that most managers are still not comfortable with statistical decision making in its various sophisticated forms, but that for what seem to the authors very good reasons, the ideas will become practical, more applicable, and in wider use by the turn of the century.

Of course, the largest and most sophisticated companies routinely have developed the quantitative side of their decision making process along with the business school theoreticians. Still, widespread use is confined to only a few companies (like GE, Shell) whose names pop up again and again in articles dealing with the subject. And even these companies do not go as far as the numbers experts would want and "err" on the side of caution.

Why has there been such reluctance on the part of the majority of practicing managers to use tools that might help them? A number of things explain the phenomenon. First, and perhaps foremost, the evidence that the formulas or techniques *always work* in practice is mixed. Managers are historically reluctant to take any risks at all if they don't have to. Because most quantitative models are literally years in the making, they are more than open to the possibility of human error. Getting the "gliches" out can take a lot of time and money. And many times they still do not work.

There is also a real ideological gap between the theoreticians who develop and understand the ideas that drive these methods and the managers who must employ the results. The theorists by and large love numbers and what their manipulation can do for managers. But, initially at least, many were impatient with lower level theories that did not always prove exactly right. So, they tested and retested, always aiming for a more perfect (and hence complex) solution to business problems. That is the essence of applied mathematics.

Understandably, however, managers are not really interested in the development of higher and higher levels of theory, but rather in what the theories can do for them in practice. In addition, they remain skeptical (in part about what they find difficult to understand) and distrust numbers somewhat because they know just how wrong their manipulation can be.

There is now a rather bizarre contradiction: While the number of computers has grown exponentially in most businesses, their importance is generally confined to the clerical and not the strategic side of management. Of course, many managers understand and can play with a word processor, or use the computer for different, simple mathematical problems; but most knowledgeable observers think that they are still not all that comfortable with the computer and especially not with its more sophisticated applications.

Part of the problem, of course, is that the managers cannot "do" much of the work involved with the mathematics of the more sophisticated kinds of techniques. The development of theorems, models, and their application is usually the job of outside consultants and/or in-house analysts. That builds in two distinct problems. The first is that the kind of expert who does the work often does not understand or get along with the manager, and has been further segregated from him or her. In addition, all those experts—and all that computer time—makes the cost of the techniques astronomic. In fact, one of the reasons some companies were burnt in the initial stages of development was that the cost of decision making techniques became too high for the kind of project for which they were ultimately used.

Will the Twain meet?

I don't think that the lack of progress in integrating higher mathematics into the decision making process spells the end of its potential contribution. In one sense, rather than signalling the uselessness of the theoretical ideas on which quantitative techniques are based, their failure to be more widely employed in practice best demonstrates how "new" they really are. Everyone has heard stories of how long certain products take to get from the lab to the consumer. Any time that theories try to break into practice, they get more flak than help. So it is with quantitative techniques. The "lab" of mathematic theorists may not have beakers and test tubes in it—but it is a lab nonetheless. What has come out of it has enormous use and potential for innovative managers who can take the time to analyze when these approaches can be profitable—and when their use is not necessary.

The important thing to remember is that the basis for mathematical application—that is, dealing with uncertainty by quantifying reality as much as possible—has something to offer managers. Both sides in this controversy should become more modest in their expectations. Theorists should learn that managers can be happiest with the simplest of theories—if they clearly can work. The best example of this may be the development by Shell of scenario analysis in its forecasting. The concept is, after all, based on one of the basic quantitative techniques, decision analysis, but the theorists have received no credit for its development because they were more interested in higher applications of the idea and tended to overlook the important aspects of it at the least sophisticated level.

Theorists must draw managers into the developmental process along every step of the way. Not only is their input necessary for the ideas to succeed, but it will also help them to understand and appreciate the rationale and potential of the theories. Managers, for their part, must be willing to take part in the development of the individual application of the technique

to their problems. In that way, they can spot obvious errors in the initial stages and add the experience that will make the application of the numbers work.

For the minds of managers to meet those of the theorists will be difficult. The techniques do not ultimately decide how a manager should act, but rather give some indication of the pitfalls to avoid. One of the best metaphors developed to explain both the possibilities and the limitations of quantitative methods is found in a paper given at the American Institute of Chemical Engineers by Albert Olenzak, director of planning and economics at Sun Company, when he referred to forecasting:

> [These ideas] are analogous to the illumination provided by the headlights of a car driving through a snowstorm at night. A bit of what lies ahead is revealed, not always clearly, so that the driver may find his way. It is not necessary for the driver to recognize every landmark and road sign, but merely to avoid danger and pick out enough detail so that he may arrive at his planned destination.

Even with this caveat, managers should remember that quantitative techniques at least can help them to order their lives and deal with uncertainty in order to make better decisions. In turn, they can learn something fundamental about the process of management. In discussing the possibilities of mathematical techniques, as well as in trying to show managers how the experts can really help them, Robert Hayes articulated the potential well:

> The crucial point is that these questions have been raised (on risk aversion, for example) by *quantitative people* [author's italics]. The focus . . . is communication, taken in its broadest sense: between different parts of an organization (the "systems approach" to organizational design) between an organization and its environment (the valuation of information) and between individuals participating in a decision process (the analysis of risk aversion.) Because of their backgrounds in exact disciplines and because the quantitative approach tends to focus on the basic *structure* of a problem rather than its situational uniqueness, they tend to think about these problems in precise terms and use precise techniques in analyzing them. The result, in many cases, is not just a new management tool, but a new conceptual framework for management, a new way of thinking.

An Introduction

Over the thirty-five years since World War II, *HBR* has published many articles explaining the theoretical rationale and possible uses of different kinds of mathematical techniques. While many of the early theories are no longer in use, we have found that the ideas driving pieces written since the early 1960s still ring true; the articles contain enough solid material to help today's manager make a decision about which technique is right for his or her use—and when.

The articles divide nicely into three groups: those that explain different theories and their rationale as well as applications in specific companies; those that talk about specific management problems, using theories as a means to solve them; and those that try to give managers pointers on how to manage the experts.

The Theoretical Foundation

The "theoretical" pieces detail the development and refinement of the most popular and widely used quantitative techniques, and how they are applied in action by selected companies. These articles have many themes or ideas in common. They religiously verify that the mathematicians did not develop theories simply to quantify reality in order to tame it, but rather to try to force the manager to grasp more realistically the complexities and possibilities of problem solving. So the first step with any of the theories is the identification of the problem, one that defies ordinary resolution but requires a decision by practicing manager. Rather than relying simply on the manager's "gut" feeling (based on experience), quantitative techniques help him or her use this experience in an ordered way, to look inside the problem, get to its heart and solve it—or make the decision—in the best way possible.

In a talk before the prestigious International Institute for Applied Systems Analysis in Laxenburg, Australia, Howard Raiffa said that the major idea behind quantitative methodology is to help managers become "more focused and penetrating" in their thinking as they proceed with an analysis toward a decision or project recommendation. Rex Brown emphasized that the importance for the manager is found (again) in "focusing informal thinking on the critical elements of a decision; forcing into the open hidden assumptions behind a decision and making clear their logical implications; providing an effective vehicle for communicating the reasoning that will underlie a recommendation."

The articles judge these kinds of qualitative insights—and not the quantitative theory—that are most important. They are never far away from the practical realities of managerial life, and try to help the manager discover the scientific way to deal with human concerns.

For example, even with the most basic technique described (PERT, program evaluation review technique, which uses simple linear programming), the major concern is "to define and successfully control complex programs"—to identify common variables that allow the manager to solve complex problems with theories. That means, of course, that the manager must learn to divide the problem into the smallest possible parts in order to conquer it.

In that regard, decision theory is most discussed because theoretically at least it gets to the heart of the issue. Because of its very nature, decision theory is known to most company managers, even if only enough to say they don't understand it.

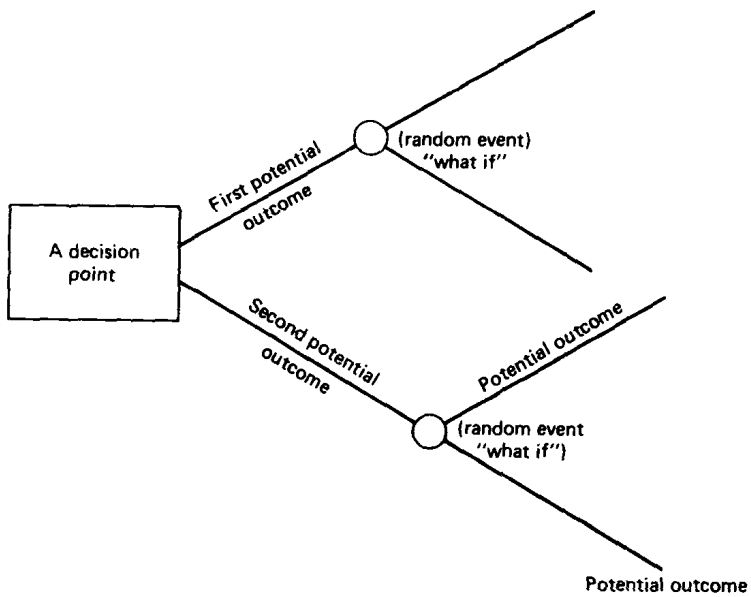
The theoretical idea starts with any simple decision (for example, to invest or not invest) and then represents the logical alternatives that come out of each such decision.

Each decision that subsequently arises when the manager tries to resolve the original problem is based on a "what if" alternative, and the probabilities that they will occur. As the analysis proceeds, the tree becomes larger and can, of course, theoretically grow to infinity. Along the way, the problem comes more clearly into focus. Rex Brown explained that the executive learns (explicitly) to:

1 Stipulate what decision alternatives are to be considered in the analysis of a problem.
2 Make a probabilistic statement of his assessment of critical uncertainties.
3 Quantify some possible consequences of various actions and his or her attitudes toward these consequences.

This information then is the meat that fleshes out the bare bones of the quantitative theory.

While managers tried to use this theory with many of their more difficult decisions, analysts were not content. They have made it more sophisticated by factoring in some of the natural uncertainty surrounding a decision. Utility or preference theory builds on the inherent notion in decision tree theory (one surrounding the theory and somewhat necessary for its success) that a



human being (in the role of manager) ultimately wants to maximize the financial value of decisions. Preference theory suggests this in an oversimplification of the real world—that every individual has a limit on the amount of risk he or she will tolerate. In other words, people will not maximize the positive monetary gains possible as much as they will try to cover themselves.

The theory then attempts to define the limits of a decision maker's tolerance to risk and, according to John Hammond, "permits the separation of two important subjective inputs to a business decision problem; namely, judgments about probabilities of events and attitudes toward risk."

A Look at the Macro Side

The decision techniques, of course, have at their heart the notion that risk or uncertainty will affect the probability that a decision will work. Other, second generation techniques help the manager to evaluate more complex questions by modeling or simulating the real world, and forecasting what will happen (on a whole range of issues). These are less interesting for discussion because they do not so much change the way managers think as they do help them in a logical fashion. Econometric models forecast the macroeconomic market for a particular product. Also included can be simulations of the interaction between the elements of particular systems. The methods used include both decision trees (used to forecast certain outcomes) and models to give the macroeconomic base.

Growing out of these kinds of forecasts have come the most sophisticated—multivariate—techniques being used today in some companies and certain sections of the government. Multivariate techniques bring the manager closer to the most scientific decision by factoring in more irrational—and less scientific—variables. At the center of these theories, too, is the notion that managers want to avoid as much risk as possible by thinking of as many contingencies as possible in advance. But the analysis attempts to help the company balance conflicting, multiple objectives that plague any major decision that involves a choice among many candidates, such as identifying a new plant site.

Multivariate methods force managers to define the different attributes that they want the ideal candidate to include—and more importantly, weigh them; then the analysts assess the performance of each real-world candidate with regard to the attributes; when conflicts occur, the method helps the analyst trade off between different attributes and calculate the value, developing a hierarchy among them.

These methods have obvious uses for the most complex decisions, when the trade offs are not easily apparent and where the decision must be broken down into the smallest components, in order to isolate the most—and discard the least—important variables.

The Practical Application

Because in theory these techniques can help a manager face most complex decisions, their application to real-world problems runs the gamut from forecasting to capital budgeting to advertising. *HBR* authors have used different forms and variations to try to teach managers how to be more effective decision makers. In that regard, the techniques eminently fulfill their promise. Perhaps most important, even when dealing with a very specific application, such as media budgets, the articles can tell all readers something about the larger technique being used (in this case preference theory) even if the particular subject is outside their field of expertise.

One note of caution. Not all the techniques used will fit neatly into one of the theoretical categories I've discussed. That is because many rely on the application of complex mathematical formulas, usually though not solely with the aid of today's computers. Others come up with their own sophisticated applications that can be used in one *particular* instance (such as Irwin Kabus's "You Can Bank on Uncertainty," which details his concept for forecasting interest rate futures). As such, they do not necessarily fill in all the theoretical blanks left by the groundbreaking theorems.

Generally, however, they show well the range and flexibility of the application of the techniques to a wide range of problems. Some help a manager out by applying a basic mathematical technique to a simple, nagging problem. William Krasker has used this method in two pieces originally published in *HBR*'s Ideas for Action column, the first on interest rate futures and the second on choosing the right technique of depreciation.

Others are somewhat broader, since they deal with more difficult and complex decisions. For example, though John Magee's "How to Use Decision Trees in Capital Investment" is clearly a finance piece, approaching capital investment in a very straightforward way, it also refines the decision tree methodology to show managers how it can be applied to a specific problem, and how their own companies can integrate their philosophy to find answers to complex questions. Along the way, Magee's advice provides this kind of insight into the art of decision methodology: "The (major) problem in laying out the decision tree is to strike the right level, the one which permits executives to consider major future alternatives without becoming so concerned with detail and refinement that the critical issues are clouded."

Other articles show that even when age-old formulas exist to solve certain management problems, the new techniques can take them one step further and closer to the best solution. In the section on production, one of the articles, ("Integrating Critical Elements of Production Planning," by John Bishop) shows how newer mathematical techniques can be helpful in revising and making an old formula for inventory control (EOQ) more effective and workable. As is generally the case with such refinements, the author starts off with the same structure but broadens its capabilities using the computer's potential, in this case allowing EOQ to take into account a