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Risk Analysis and its Applications



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David B. Hertz

Formerly a Director and Partner of McKinsey & Co.

and

Howard Thomas

University of Illinois at Urbana — Champaign



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*Risk Analysis and
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Preface

This project developed through an association which began in the early 1970s, when David Hertz, then a partner in McKinsey and Co., Management Consultants, and also an adjunct professor at Columbia University, spent two periods as a visiting professor at London Business School (LBS). At that time, Howard Thomas was a faculty member at LBS and Director of the Decision Analysis Group, funded primarily by the UK Social Sciences Research Council. David's assignment at LBS was to teach special elective courses in risk analysis and planning under uncertainty on London's MBA (MSc) program. Howard later became the coordinator and joint instructor for these courses on the basis of his research interests and David's peripatetic consulting schedule.

During this period we were encouraged by various practitioners, businessmen and students who suggested that we should write practically oriented book(s) on our elective subjects. As we discussed the idea, the belief grew that any such text should appeal equally well to business majors, MBAs, and executive program students. Subsequently we met up with Jamie Cameron of John Wiley and Sons, our publishers, who was excited not only about the risk analysis project, but also by the concept of a planning under uncertainty text, which, incidentally, Wiley will also be publishing shortly after the appearance of this volume.

Over the succeeding years we crossed paths many times; for example, whilst jointly conducting a risk analysis seminar at the Spanish business school, IESE, and again while HT was a visiting professor in the United States. During this period, we both had ample opportunity to develop a broadly-based coverage and knowledge of a wide range of applications. This has been possible through such activities as consulting, teaching, and research contract work. In addition, during the period of HT's appointment as a Foundation Professor at the Australian Graduate School of Management in Sydney, he was able to develop work within Australian and Far East contexts, while at the same time continuing to work with DH in the American and European environment. Throughout this time, working drafts of case and textual material have been routinely exchanged. The final version of the manuscript is fully consistent with our initial objectives, and has benefited considerably from the extended time horizon between project idea and completion.

Those initial objectives were:

- (i) To develop David's original *Harvard Business Review* (*HBR*) articles: 'Risk Analysis in Capital Investment' (1964), and 'Investment Policies that Pay Off' (1968). Incidentally, 'Risk Analysis in Capital Investment' was reprinted as an *HBR* classic, not only to mark its importance, but also to acknowledge the sale of 150,000 reprint copies by the *Review*.
- (ii) To present a broad understanding of the risk analysis approach and its potential areas of application. That is, the aim of the book is not to present an argument in relation to the theory of finance, but rather to offer a strategic thinking methodology which might encourage decision-makers to examine carefully the data and assumptions surrounding a decision problem such as an investment project. In other words, the textbook is not intended to serve as a toolkit for financial decision-making.
- (iii) To develop the book's applied perspective through the use of a series of real-life case examples, which have been written up as case histories. This approach has been adopted in an effort to improve the flow of the textual exposition of the risk analysis approach
- (iv) To publish simultaneously a companion volume, entitled *Practical Risk Analysis*, which would provide readers and students with an opportunity to test their mastery of risk analysis in a 'learning by doing' sense.

We believe that risk analysis, viewed as a broad approach for handling uncertainty, is now routine and commonplace in business and public decisions. Indeed, we believe that the approach encourages business and public decision-makers to understand risk more effectively, thereby making them more willing to take some calculated risks. Risk analysis is not aimed at *eliminating* uncertainty, or even *minimizing* it, but rather at encouraging entrepreneurial activity through a better awareness of risk.

Our position is put very clearly by Peter Drucker (1) in this extract from his essay on 'The Manager and the Management Sciences':

The fear of risk-taking

To try to eliminate risk in business enterprise is futile. Risk is inherent in the commitment of present resources to future expectations. Indeed, economic progress can be defined as the ability to take greater risks. The attempt to eliminate risks, even the attempt to minimize them, can only make them irrational and unbearable. It can only result in the greatest risk of all: rigidity.

The main goal of a management science must be to enable business to take the right risk. Indeed, it must be to enable business to take *greater* risks — by

providing knowledge and understanding of alternative risks and alternative expectations: by identifying the resources and efforts needed for desired results; by mobilizing energies for contribution; and by measuring results against expectations, thereby providing means for early corrections of wrong or inadequate decisions.

All this may sound like mere quibbling over terms. Yet the terminology of risk minimization does induce a decided animus against risk-taking and risk-making — that is, against business enterprise — in the literature of the management sciences. Much of it echoes the tone of the technocrats of a generation ago. For it wants to subordinate business to technique, and it seems to see economic activity as a sphere of physical determination rather than as an affirmation and exercise of responsible freedom and decision.

This is worse than being wrong. This is lack of respect for one's subject matter — the one thing no science can afford and no scientist can survive. Even the best and most serious work of good and serious people — and there is no lack of them in the management sciences — is bound to be vitiated by it.

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Chapters 2 and 3 use cases, namely 'Aztech Electronics' and 'Property Development in Caracas' developed primarily by Howard Thomas whilst at London Business School. They were originally published in *Case Studies in Decision Analysis* by P. G. Moore, H. Thomas, D. W. Bunn and J. M. Hampton and are reproduced here by permission of Penguin Books Ltd., London, SW10 0UH, England.

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The Mucom Case in Chapter 6 was originally written by Professor Gordon Kaufman of the Sloan School of Management, MIT, and is used here with permission.

Chapter 8 uses extracts from an article 'Management Science and the Chief Executive' by David B. Hertz (*Management Decision*, 1972). It is reproduced here by permission of the Editor, *Management Decision*.

We also owe a great intellectual debt to other scholars with whom we have been associated. Notably, Professor Peter Moore, Deputy Principal of London Business School and joint Director (with H.T.) of the Decision Analysis Unit at L.B.S., Professor Gordon Kaufman of MIT, Professor Larry Phillips of Brunel University and the London School of Economics, Professor Howard Raiffa, Frank P. Ramsey, Professor at Harvard Business School, Professor Robert Winkler of Indiana University, Dr. Rex Brown of Decision Science Consortium, Dr. Michael Menke, formerly of SRI and Dr. Ralph Keeney of Woodward–Clyde. Members of the Decision Analysis Group at London Business School in the 1970s, namely, Derek Bunn, Juliet Hampton, John Hull, Andrew Lock, Paul Morris and Peter Burville, also deserve particular mention. Clearly their influence on our thinking and work has been important, stimulating and valuable.

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Introduction: The Book, Issues, Definitions, and Scope

1. WHAT WE UNDERSTAND BY THE TERM 'RISK ANALYSIS'

Decision and Risk Analysis as Strategic Thinking Frameworks

Decision and risk analysis (Hertz (2), Thomas (6), Raiffa (5)) can be viewed as having two major roles. Firstly, it offers a broad perspective for structuring the process of decision-making, and secondly, it provides a set of techniques for evaluating the worth of alternative decision options. Both analytic approaches involve *decomposing and structuring the problem*, assessing the *uncertainties and values* of the possible outcomes, and the *determination of the preferred strategy* in terms of some specified choice criteria.

We believe that within the organizational context there is a close connection between decision and risk analysis, and policy and strategy formulation. Further, we believe that risk analysis should be able to add a valuable contribution in terms of providing strategic thinking input for a process of policy dialogue about the decision situation. Such input should be iterative, adaptive, and flexible, while at the same time providing a 'thinking structure' for policy/strategy problems. It is further contended that there is no meaningful distinction between analytic approaches such as risk analysis — which develops an awareness of the impacts of risk and uncertainty on decision problems — and processes of policy/strategy formulation concerned with the resolution of these problems. They should both be seen as valuable parts of *policy dialogue* prior to final decisions being taken.

Risk Analysis Defined

The term 'risk analysis' is used here to denote methods which aim to develop a comprehensive understanding and awareness of the risk associated with a particular variable of interest (be it a payoff measure, a cash flow profile, or a macroeconomic forecast). In other words, a forecast is obtained for a variable of interest in the form of a probability distribution. Two solution techniques are most commonly used to generate the required forecast probability profile. An analytical approach might be adopted. Using this technique, individual

forecasts are combined (according to a specified structural model) using statistical distribution theory (often in relation to such standard distributions as the normal distribution) to calculate the mean and variance parameters of the probability distribution of the final criterion variable (usually a payoff measure). The other technique most frequently used is to adopt a Monte-Carlo-type simulation approach using the structural model. This model specifies the set of equations required to combine the input probabilistic variables into the distribution of the final payoff measure.

Typically, not all of the inputs need to be specified as probabilistic variables because a preliminary *sensitivity analysis* is often used to screen and identify those input variables which need to be specified in probabilistic form.

Risk analysis has, perhaps, found the greatest immediate acceptance in the area of investment project appraisal. The reason for this may be that it is in such areas that managers frequently have to confront the possibility of making the wrong decision and experiencing 'negative' outcomes such as financial loss. Although risk analysis is useful in this area, it is possible that many readers of the original Harvard Business Review (HBR) articles (Hertz (2)) wrongly interpreted risk analysis as an argument in methodology about investment decision-making. Unfortunately, by concentrating on this aspect, some people may have missed the broader perspective of risk analysis: that is, as a vehicle for examining the data surrounding a decision problem (which might very often be an investment proposal) in the light of all the pervasive uncertainties of the world, of which business is simply one part. In other words, we see a broad role for risk analysis in terms of strategic thinking about decision problems. Risk analysis is as important a vehicle in planning, forecasting, understanding, and handling uncertainty, as it may seem to be in the area of financial decision-making.

Risk analysis has a valuable role to play in the management of the strategic process through its input into such areas as: *forecasting and planning*, *risk positioning* for the firm, *scanning* of the uncertain business environment, *scenario development* in relation to potential social, political, economic, and technological futures, and the *handling of risk and uncertainty*, which are increasingly stressed in modern strategic management paradigms, e.g. Hofer and Schendel (3).

It should be noted that the risk analysis method emphasizes the value of managerial judgement in both input estimation and decision. Our experience suggests that the variety of information available from a risk analysis is useful in two main areas. Firstly, it is a valuable aid in clarifying managerial assumptions about the nature of the decision problem and consequent implications, and secondly, it is an invaluable tool for improving communication, debate and dialogue about the problem (i.e. its assumptions, structure, etc.) amongst the managerial team, and also between managers and analysts. We believe this improved communication to be one of the major benefits to be gained as a result of using risk analysis.

However, we are not suggesting that risk analysis should ever be considered

as a meaningful substitute for managerial judgement. The contribution which risk analysis can make is to help managers' thinking processes, and this is done in the first instance by forcing them to confront the structure of the decision problem in a relatively unemotional manner. After the problem has been defined, a 'first-pass' risk analysis can facilitate various activities: it can successively assess the range of uncertain variables deemed important, gather any information required which bears on the resolution of the problem, exhaustively evaluate the cross-impacts amongst the uncertain variables, and combine key uncertain variables to identify viable decision paths and options for the organization in terms of specified preference and choice criteria. Ultimately, it enables the decision-maker — business executive, government administrator, scientist, legislator — to examine, discuss, and eventually understand why one course of action might be more desirable than another.

2. SOME DEFINITIONS

Meaning of Risk and Uncertainty

As used in this book, *risk* means both uncertainty, and the results of uncertainty. That is, risk refers to a lack of predictability about structure, outcomes or consequences in a decision or planning situation. Risk is therefore related to concepts of chance such as the probability of loss or the probability of ruin.

Some earlier writers in the field drew a distinction between risk and uncertainty in the following manner. A risk situation is argued as one in which a probability distribution for outcomes is made on a meaningful basis, agreed upon by the set of relevant experts, and is, therefore, 'known'. Uncertainty situations arise, therefore, when a consensus agreement amongst the set of experts cannot be achieved, i.e. there is an unknown, undefined probability distribution on the set of outcomes.

Lindley (4) points out that a different and more useful form of distinction is often drawn between events which are *statistical* and those which are not. Statistical events are defined to be capable of very extensive repetition, whereas non-statistical events are essentially unique. However, many decision situations are unique and refer to choice on one occasion, so that decision-makers are not often confronted by repeatable situations. Thus, decision-makers must often make 'non-statistical' or subjective probability assessments which are consistent and coherent in terms of the laws of probability (and can, therefore, be compared with so-called 'statistical' or objective probabilities) in order to represent the uncertainty which exists in decision situations.

The purpose of the above is simply to illustrate that while distinctions between risk and uncertainty, or statistical and non-statistical events, are useful in conceptual terms, they have limited value in the practical process of risk assessment and analysis. Indeed, concepts of strategic risk must reflect the realities of strategic decision situations. That is, they must recognize such issues

as the quality of information available to decision-makers and the importance of outcomes and organizational goals.

Therefore, our concept of strategic risk recognizes that strategic decision-making situations involve 'structural uncertainty'. In other words, there is considerable uncertainty about the formulation of the problem in terms of its structure and underlying assumptions. As a result, the definition of risk here is broadened to include both the lack of predictability about outcomes and also *all* of the elements of problem structure. This includes such factors as the relevance of assumptions, the generation of strategic alternatives, the level of organizational information about the problem, the importance of consequences and the ability to attain various organizational goals.

Decision Criteria

In this text we assume that the reader has an acquaintance with such investment decision-making criteria as Net Present Value (NPV), Internal Rate of Return (IRR), and Payback. However, some useful review material can be found in Copeland and Weston (1) and Van Horne (7). In financial decision-making contexts we shall follow the finance literature and adopt NPV as the most appropriate and valuable worth criterion.

We should also point out, however, that as our concept of risk analysis applies to a wide range of decision situations, there may be other criteria which can be used in choosing the most sensible strategy paths. For example, the decision criterion may be multi-attributed, as in cost/benefit analysis applications, or based on a time profile of cash flows as, for example, for an organizational growth strategy path.

3. ISSUES ASSOCIATED WITH THE RISK ANALYSIS APPROACH

Problem Finding and Structuring

The preliminary pre-decisional effort involved in problem identification, i.e. in the modelling and structuring phase, is the most important, worthwhile but often least stressed activity amongst all stages of the decision and risk analysis approach. In our experience, it is clear that well over half the time and effort in any analysis should be spent on structuring the problem.

Reference to earlier writing on decision and risk analysis, including our own, indicates that such structuring skills can often only be 'learned by doing'. That is, such skills may often only be acquired through experience in decision and risk analysis. Such a view suggests that if a taxonomy of problem types, e.g. new product, manufacturing investment, etc. were available, the problem-solver could be aided in his early analysis by having the opportunity to match his particular decision problem with one of the problem types catalogued within the firm or literature. In other words, if more risk analysis applications were