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Introduction

Tesman: But good heavens, we know nothing of the future.

Løvborg: No, but there is a thing or two to be said about it all the same.

Ibsen: *Hedda Gabler*

1.1 The background

Risk is about future happenings and enters everybody's lives at numerous points. A mountaineer going on an expedition can break a leg, or be killed. A business person keeping an appointment in Birmingham may be involved in a serious road accident. A traveller in Africa may contract dysentery. A gambler entering a casino could lose all his capital in a night. The company in which an individual has invested may go into liquidation. An entrepreneur starting a new business venture can lose his capital when an expected market fails to materialize. A government may be thrown off course when a major trading bloc operates a cartel against it.

Economic progress is impossible without taking risks; indeed it is arguable that even the maintenance of an economic status quo involves risk taking. Hence risk has about it an aura of achievement and progress, communities commonly rewarding those who handle difficult risk situations successfully. Effective handling of risks requires first their assessment and, secondly, their subsequent incorporation in the decision-making process. Exploring these themes in a variety of business, economic, political and social settings forms the primary objective of this book.

To take an action involving a risk is to take a chance or a gamble; it implies a degree of uncertainty and inability to control fully the outcomes or consequences of such an action. Sometimes the chances of benefit are low and it's only just possible the risk will pay off. At other times the chances are high: it's very likely the desired outcome will occur. Faced with a choice of courses of action, with differing levels of risks and possible rewards, a decision has to be made as to what to do. The more the precise nature and level of the risks faced can be revealed the better informed the decision made will be. But if hunches are followed – flying by the seat of the pants – then outcomes may occur that sometimes surprise both the decision maker and his colleagues.

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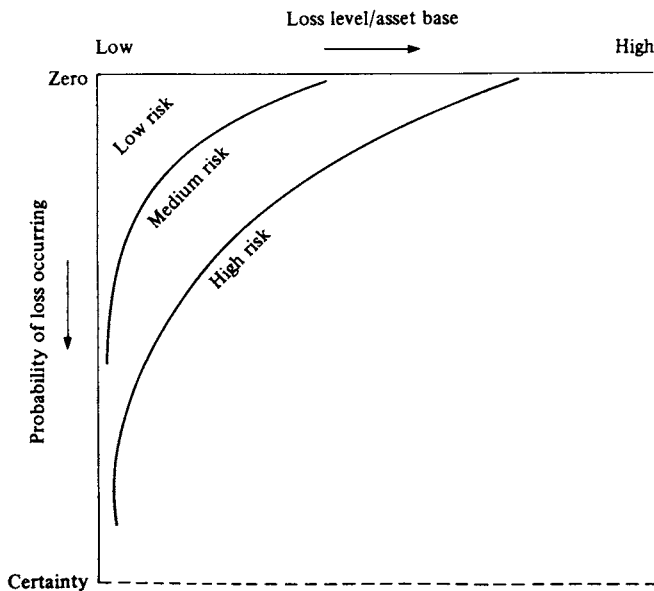
Risk is a ‘portmanteau’ word. It describes a scenario in which possible losses are present: physical (such as death), disappointment (failure to climb a mountain), financial loss (as when a business person makes a poor investment in a new venture). Higher risk makes the loss more likely, lower risk makes it less likely. Sometimes risk has a different meaning as being the precise quantum of money that can be lost by undertaking some venture. For example, insuring household possessions against loss by theft for £5000 leads the insurance company (or the underwriter on its behalf) to regard the sum of £5000 as being *at risk*. To them risk is the maximum monetary loss the company can incur.

The word ‘risk’ is relatively modern, coming to England in the mid-seventeenth century from France as the word *risque*. The anglicized spelling began to appear in England around 1830 in insurance transactions, and for about 100 years the two spellings existed side by side. Only in the twentieth century has the derivative *risqué* become the word for a joke that risks offending. In earlier days, before the word risk existed, the word *hazard* appears to have had the closest meaning as in Shakespeare’s *Merchant of Venice*:

Men that hazard all do it in hope of fair advantages.

Hazard and risk can both be used as either a noun or a verb and so both

Figure 1.1. Risk Levels



1.1. *The background*

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are capable of expressing two ideas: first, a danger located in some aspect of the external world and, second, the idea of acting in a way that involves the taking of a chance. But Shakespeare reminds us that risk is connected not only with the possibility of loss or harm, but also with the hope of some benefit or gain.

There are thus two basic components of risk: first, a future outcome which can take a number of forms, some of them commonly unfavourable; and, second, a non-zero chance that the less favourable outcome(s) may occur. Colloquially, risk is used to cover the combination of an unfavourable result and the non-zero chance of its occurring. However, when terms like 'high risk' or 'low risk' are used, the meaning commonly depends on the starting asset base and the consequences that the occurrence of the 'risk' would have for the asset base of the individual or organization concerned. The position can be viewed simplistically on an asset-free basis by postulating the loss level as being expressed as a multiple (or ratio) of the asset base. Figure 1.1 illustrates schematically the combinations of probability of loss against level of loss that lead to so-called high-risk situations and the duality implied by the use of the term risk in the two dimensions. The boundary lines are indicative of the kinds of situations colloquially labelled with the various degrees of risk.

The word *risk* is used in either sense in this book where its connotation is clear, but otherwise the words *probability* or *chance* are used for one dimension, with the words *value*, *payoff*, *gain* or *loss* for the other dimension.

1.2 **Some thumbnail sketches**

Brief thumbnail sketches illustrate the problems discussed in this book.

Oil exploration

An area of land or sea is to be allocated by the Government to the highest bidder, entitling them to explore for oil in that area. An oil company is deciding whether to put in a bid for drilling on the area and, if so, what level of bid to make. If oil is found they can develop the site and sell the oil, subject to various taxation provisions on the proceeds. Clearly the price bid for the area is linked both to the assessed probability of striking oil and, secondly, to the likely proceeds from raising and marketing the oil found. The chance of any individual borehole striking oil is low; furthermore, as more ground is explored, the chance of further successful boring diminishes, as the more promising areas will usually be the first to be explored.

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The risk in drilling cannot be eliminated – and an area that has no oil cannot magically be given some – but the possibility of purchasing a dud area can be reduced in a number of ways, for example by a study of geological conditions already found in neighbouring blocks, seismic soundings, etc. If taxation of the financial proceeds is raised in real terms, exploration activity could be expected to diminish, and lower prices paid for areas. This feature is sometimes referred to as a lowering of the reward/risk ratio: a concept that seems to have been borne out in recent years when rises in the real level of taxation of oil revenues have led to a slowing down of exploration and development activity in the North Sea, albeit to the surprise of some politicians.

A lending decision

A finance house has a funding proposal from an entrepreneur interested in manufacturing and marketing a jig which enables any amateur do-it-yourself enthusiast to build wardrobes, kitchen units, bookcases, etc. to professional standards. The entrepreneur, a biologist by background, has run a textile retailing business for eight years and wishes to raise £100 000 to set up his own company. The finance company is concerned with the safety of both capital and interest for any funds it advances. This involves assessing the risks centred around the production capabilities, the market potential, the financial structure, and the managerial potential of the entrepreneur and the team he either has, or proposes to recruit. Only when these assessments have been made will the finance company be in a position to make a decision as to the terms on which any financial backing could be given.

Pharmaceutical launch

A pharmaceutical company plans to launch a new drug on the market. The problem is the size and scope of the product launch. Various methods are available to generate publicity: advertising; television commercials; direct mail; free samples to doctors and others; special shop displays; doorstep promotion; etc. These may be used singly or in combination, and at differing intensities. The costs of alternative media are known and, while the effectiveness of each medium can be estimated from information on past launches, no two launches are precisely similar. The number of combinations of publicity options is immense, but for each there are differing degrees of uncertainty about their effectiveness. From all this information a launch plan has to be decided upon.

1.2. *Some thumbnail sketches*

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Fruit cargoes

The purchasing manager of a fruit-importing business is deciding what to do about forward dealings in grapefruit for next January. Only two cargoes of grapefruit, of different sizes, are due in London next January. He can purchase either cargo, but for cash reasons not both, provided he contracts quickly. He always has the opportunity of spot purchases, albeit at a higher price than for a full cargo. There are two big customers who will decide their contracted requirements in about a month, after the decision regarding the cargoes has had to be made. If the manager signs for one of the cargoes, and then fails to win a sales contract, he could sell small quantities at a good price, but larger quantities would have to be sold at clearance prices. What is his optimal strategy?

Tourism

An American property company is looking at the possibilities of various development schemes within the Caribbean area. With the rapid growth of tourism and the increasing wealth of the area, a number of options are identified:

- (a) a mix of office and apartment development activity;
- (b) residential developments: apartments and homes;
- (c) hotel and leisure park developments.

The major uncertainties revolve around the inherent political risks, i.e. the likelihood of government stability, of revolution, of subsequent military takeover, of changes in laws and, ultimately, the chance of appropriation of assets. Quite apart from these crucial sources of uncertainty, the company is also concerned with the chances of obtaining suitable short-term and long-term financing, the likely development costs, the speed with which planning permission can be obtained, and the number of potential users of the proposed developments. In addition, the development of a good transport infrastructure and the degree of willingness of international airlines to route more airplanes to this area could affect the profitability of the operation considerably. Which option or options should be pursued?

Diagnosis

A doctor does not know whether his patient's sore throat is caused by streptococcus or by a virus. If it were strep, he would prescribe penicillin pills or an injection, whereas if it were a virus he would prescribe rest, gargle and aspirin. Failure to treat a strep throat by penicillin (or other drugs) may result in a serious disease, such as nephritis. However, penicillin must not be administered indiscriminately since it could result in a serious

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penicillin reaction causing extreme discomfort, while penicillin-resistant bacteria might later develop.

A throat culture can be taken to indicate presence or absence of strep but the test is imperfect. The doctor even then still has a variety of ways to treat the patient. He can prescribe penicillin pills, or rest and gargle. How should he decide among these alternatives?

Television series production

A United States film company is contemplating a new twelve-episode film series for television based on Abe Bayley's novel entitled *The Dollar Game*: an exposé of the workings of a finance house. The company has approached one of the major US television networks for financial backing.

The network concerned is considering whether, and how much, to invest in the series and faces a number of uncertainties in reaching its decision. These relate primarily to the costs of production, the availability of outside financial backing, the level of viewing audience that will be attracted, the pulling power to potential advertisers, the availability of artists to play the lead roles in the series, and the sales potential of the series to networks outside the United States.

Faced with such uncertainties, the network is considering yet another option, namely to contract for one or two pilot episodes only, using these to evaluate more clearly the likely viewing audience and the advertising potential of the complete series. The sums of money involved are large, combined with inherent high risks as to the return.

Road programme

A limited amount of money is available for spending on roads and road improvements over the next three years. Various alternative programmes have been put forward and it is necessary to choose between them. In making this choice, a number of possible considerations emerge. First, there are the general benefits to traffic flow, both for through traffic and for local traffic; second, the amelioration of bottlenecks; third, the reduction of accidents; fourth, the public reaction to the ways in which they perceive priorities being defined and their money being spent. By taking all these factors into account, with the various consequences, many of which are only quantifiable in terms of expectations, a specific programme has to be selected.

1.3 Substitution of risks

The examples described suggest that efforts should be made to reduce (or even eliminate) some or all of the risks involved. However, eliminating, or reducing, one risk can sometimes mean an increase in another risk. Numerous illustrations where this kind of trade-off has to be made occur in this book, so just two instances will be mentioned at this stage. The first relates to the insect killer DDT. Unlike some other insect killers, DDT does not decompose readily into harmless constituents. Rachel Carson wrote an emotive book *The Silent Spring* in the 1950s (Hamish Hamilton, 1963) about the potential dangers of DDT and other insecticides and weed-killers to human beings. Partly as a result, Ceylon (Sri Lanka) banned DDT. Shortly afterwards Ceylon had a raging and virulent epidemic of malaria, a disease transmitted by mosquitoes. At that time the disease could have been controlled, and possibly virtually eliminated, by DDT. Many people in Ceylon therefore died unnecessarily because it had become possible to develop ways of measuring as little as 1 part in 10 million of DDT and its use in some form to control malaria thus became possible. The pursuit of a no-risk society in one sense had increased the risks in another sense.

A second example relates to crash helmets for motor cyclists, for which a British Standard was introduced some 20 years ago. This standard was widely misunderstood initially on two counts. First, there was inadequate realisation that part of the protection when a crash happens comes from the absorption of shock by the breaking of the helmet on impact. A broken helmet is not proof of an ineffective helmet: indeed it could be the opposite. Second, it was insufficiently appreciated that, while a stronger and more rigid helmet could in theory protect the head better, it would mean there was a greater chance that the motor cyclist whose skull is saved would instead seriously dislocate his neck. Thus ameliorating one risk could expose another equally lethal risk.

1.4 Risk and probability

The word 'chance' has been used earlier in relation to some happening that cannot be predicted with absolute certainty. The more common way of expressing such chance is by means of the term *probability*. An outcome that must occur is given the probability value 1, while an outcome that cannot occur under any circumstances is given the probability value 0. All other outcomes have probabilities that fall somewhere between 0 and 1. Suppose that in taking some specific course of action a particular outcome is given the probability value 0.3. Subsequently this outcome either does or does not occur, and from the result one won't be much wiser

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as to whether the original probability value 0.3 was indeed 'correct' or not. Over a period of time, however, all situations where the probability value used was 0.3 could be put together and looked at as a set. In this set it should be found that in about 30% of the cases the named occurrences had occurred, while in about 70% they hadn't. A large number of 'probability 0.3' situations would have to be considered to achieve a precise match but, as the number of situations or trials increases, so should the closeness between the observed outcomes and the probability concerned.

The value of 0.3 for the probability in an individual situation can be reached in a variety of ways. Many of these are examined later in Chapters 2 to 4. But, however the probability is arrived at, it must always obey a number of basic rules of behaviour such as coherence and consistency. For example, suppose that an insurance company rates the probability of a male driver insured with them having an accident in a given year as 1 in 10 (0.1), with the equivalent probability for a female driver being 1 in 15 (0.067). Of the policyholders on its books, two-thirds are men and one-third are women. Then the overall probability of a policyholder chosen at random from among all the policyholders having an accident in a given year is equal to $\frac{2}{3} \times 0.1 + \frac{1}{3} \times 0.067$, or 0.089. This result does not depend on the processes used to determine the two probabilities. It simply states that, if these two separate probabilities are given, then the consequence derived above follows. If the consequence is untrue, this implies that one or other – or both – of the original probabilities must themselves be incorrect.

Appendix A demonstrates the basic rules that have to be obeyed by probabilities, and the ways in which appropriate probabilities for complex combinations of events be derived from the component probabilities if coherence and consistency is to be maintained.

1.5 **Decision analysis**

Decision analysis forces decision makers to carry out a thorough and logical evaluation of the alternative strategies open to them, so that the 'best' available strategy in terms of some stated preference criteria for choice among the alternatives is selected. It provides a framework for taking decisions in an environment of risk and uncertainty.

The decision maker goes through five stages in this process (see for example, Raiffa, 1968). The stages do not always need to be rigidly followed and, indeed, some may occasionally be redundant. The value of the step-by-step procedure lies in its power to force the decision maker to conceptualize the structure of decision problems in a coherent and meaningful way. The five stages are as follows.

1.5. *Decision analysis*

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Stage 1: Structuring through decomposition

The decision maker first decomposes a complex decision problem into a series of simpler and more individually manageable decision problems. Such a decomposition is commonly shown in the form of a kind of flow diagram known as a *decision tree*. Figure 1.2a shows a typical tree. The essence of it is that, no matter how complex the decision problem, the decision maker is forced to define the problem clearly, to consider all feasible alternatives and to clarify the nature of the outcomes that can arise from each alternative course of action. Structuring is both art and science, and cannot easily be taught as a series of rules. In practice, decision makers improve their structuring skills through ‘learning by doing’.

Stage 2: Assessing payoff (or utility) values

The decision maker evaluates the payoffs for each end-position on his decision tree. These payoffs will commonly be in terms of the net gain (or loss) for the unique route along the tree leading to the particular end point concerned. This net gain will be income less expenditure although, if the project spans a substantial time span, both income and expenditure would be discounted to the same point in time (commonly the start date). When decision makers do not regard money on a linear scale (for example, they attach greater importance to increasing their assets from £1 million to £2 million, than in increasing them from £2 million to £3 million) then some utility scale has to be used in place of payoff. This need is discussed in Chapter 5, where situations whose outcomes are judged on more than one dimension, for example monetary return and maintenance of employment, are also considered.

Stage 3: Assessing probabilities for uncertain outcomes

Judgements about the chances of various outcomes arising from particular courses of action are quantified in terms of probabilities. Considerable evidence exists that decision makers use probability concepts effectively when assessing uncertainties for their analyses of decision problems, once they have had experience in the processes involved. Procedures for assessing probabilities in various forms are available (see Chapters 3 to 5). Much attention has been devoted in recent years to understanding the biases which occur in probability assessments, and to seeking approaches that simplify the assessment task.

Stage 4: The roll-back process

The solution procedure followed is based on the principle of optimality used in dynamic programming. It involves calculating expected values for each alternative course of action at the appropriate points on

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the decision tree, expected value being commonly referred to as *expected monetary value* (EMV), even when the payoffs are not expressed in strict monetary terms. Roll-back then operates by working from the end points (right hand side) of the decision tree and folding it back towards the start (left hand side), choosing at each decision point the course of action with the highest expected value. By repeated application of this principle until the start point is reached, all alternatives are eventually eliminated except the 'best' strategy. Decision analysis rests upon the principle that no other decision rule exists that will, used consistently over time for all decisions, achieve a higher payoff.

Stage 5: Sensitivity analysis

In any decision analysis the quality of the deduced strategy depends primarily upon the quality of the judgements both of probability and the outcome valuations on which the analysis is based. (This, incidentally, is true whatever decision-making approach is adopted.) To meet this concern the decision maker should examine the sensitivity of the derived strategy to possible variations in the judgemental inputs. The crucial factors in the decision situation can be readily identified in this way, and extra assessment effort concentrated on the more sensitive factors.

1.6 An illustrative example

The concepts of decision analysis are illustrated with an example of a company deciding whether or not to invest £130000 in a one-year research and development (R&D) project aimed at developing a new product. If the project is successful, the company can choose between building a plant capable of producing 100000 units per annum or one capable of producing 200000 units per annum.

Figure 1.2*a* shows the decision tree defining the situation. There are two kinds of node on the tree. The square-shaped *decision nodes* represent points in time where a choice has to be made between alternative courses of action. The circular *outcome nodes* represent points in time where the outcomes which occur from decisions already made are not completely within the control of the decision maker.

The first node at *A* is a decision node, and the two branches emanating from it indicate that the company can choose whether or not to go ahead with the R & D programme. If the company does not go ahead, there are no further decisions, and outcomes are unimportant. (Hence the 'not go ahead with R & D' branch leads to no further branches.) If the company goes ahead with the R & D, the tree shows at node *X* that there are then two possible outcomes: 'R & D successful' and 'R & D unsuccessful'. If