A Lexicon of Decision Making

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It may not seem very important, I know,
but it is, and that's why I'm bothering telling you so.

--Dr. Seuss

Introduction

A **decision** is an allocation of resources. It can be likened to writing a check and delivering it to the payee. It is irrevocable, except that a new decision may reverse it.

In the same way that a check is signed by the account owner, a decision is made by the **decision maker**. The decision maker is one who has authority over the resources being allocated. Presumably, he (or she) makes the decision in order to further some **objective**, which is what he hopes to achieve by allocating the resources.

> *Key distinction: **decision** vs. **objective***
>
> *Example: To accelerate an R&D program is an objective, not a decision. To allocate the funds in an effort to accelerate the program is a decision.*
>
> *Why it's important: The decision might not succeed in achieving the objective. One might spend the funds and yet, for any number of reasons, achieve no acceleration at all.*

The decision maker will make decisions consistent with his **values**, which are those things that are important to him, especially those that are relevant to this decision. A common value is economic, according to which the decision maker will attempt to increase his wealth. Others might be personal, such as happiness or security, or social, such as fairness.

The decision maker might set a **goal** for his decision, which is a specific degree of satisfaction of a given objective. For example, the objective of the decision might be to increase wealth, and the goal might be to make a million dollars.

A decision maker might employ **decision analysis**, which is a structured way of thinking about how the action taken in the current decision would lead to a result. In doing this, one distinguishes three features of the situation: the decision to be made, the chance and unknown events which can affect the result, and the result itself. Decision analysis then constructs **models**, logical and perhaps even mathematical representations of the relationships within and between these three features of the decision situation. The models then allow the decision maker to estimate the possible implications of each course of action that he might take, so that he can better understand the relationship between his actions and his objectives.

The three features of a decision situation

At the time of the decision, the decision maker has available to him at least two **alternatives**, which are the courses

of action that he *might* take. When he chooses an alternative and commits to it (i.e., signs and delivers the check), he has made the decision and then **uncertainties** come into play. These are those uncontrollable elements that we sometimes call luck. Different alternatives that the decision maker might choose might subject him to different uncertainties, but in every case the alternatives combine with the uncertainties to produce the **outcome**. The outcome is the result of the decision situation and is measured on the scale of the decision maker's values. Since the outcome is the result not only of the chosen alternative but also of the uncertainties, it is itself an uncertainty. For example, an objective might be to increase wealth, but any alternative intended to lead to that outcome might lead instead to poverty.

Key distinction: ***good decision*** *vs.* ***good outcome***

Example: Someone who buys a lottery ticket and wins the lottery obtains a good outcome. Yet, the decision to buy the lottery ticket may or may not have been a good decision.

Why it's important: A bad decision may lead to a good outcome and conversely a good decision may lead to a bad outcome. The quality of a decision must be evaluated on the basis of the decision maker's alternatives, information, values, and logic at the time the decision was made.

Types of decisions

A **simple decision** is one in which there is only one decision to be made, even though there might be many alternatives. An example of this is the very limited consideration of purchasing collision insurance for an automobile. The decision maker might be interested only in comparing three alternatives, such as no insurance, insurance with $100 deductible, or a policy with $500 deductible. If at the same time we attempt to add another decision, we have created a problem of **strategy**, which is a situation in which several decisions are to be made at the same time. Each of the decisions in the strategy will have different alternatives, and the decision maker will attempt to choose a coherent combination of alternatives. For example, if the decision maker is considering whether to buy a new car or keep his 10-year old one, and at the same time he is considering the insurance decision, he might compare only two candidate strategies: keep the old car and not buy collision insurance, or buy a new car and buy some level of collision insurance.

Key distinction: ***strategy*** *vs.* ***goal***

Example: Launching two new products a year is a goal. Investing in additional personnel, while at the same time stopping the funding of some stalled projects, is a strategy intended to lead to that goal.

Why it's important: Strategy describes a collection of actions that the decision maker takes. The outcome of the actions is uncertain, but one of the possible outcomes is attainment of that goal.

An important special case of a strategy problem is the **portfolio** problem, in which the various decisions faced in the strategy are of a similar nature, and the decision maker does not have sufficient resources for funding all combinations of alternatives. An example is an investment portfolio, in which the decision maker is aware of a good number of investments he would like to make, but is unable to afford all of them. Especially in situations like this example, people sometimes address the problem as one of performing a **prioritization** of the various opportunities. If one opportunity is prioritized higher than another, then, in the case of limited resources, the decision maker would prefer to invest in the former than in the latter.

Key distinction: ***decision*** *vs.* ***prioritization***

Example: To assert that one would rather fund development project A than development project B, and project B than project C, is a prioritization. Actually funding project A is a decision.

Why it's important: A prioritization might be an intermediate step en route to a decision, and one might even use a prioritization as a tool to aid in a decision.

Some decisions offer the opportunity to adopt a particular type of alternative called an **option**. An option is an alternative that permits a future decision following revelation of information. All options are alternatives, but not all alternatives are options.

Key distinction: ***alternative*** *vs.* ***option***

Example: To allocate the resources needed to drill an oil well is an alternative. To pay money now to reserve the right to drill after geological testing is done is an alternative that is also an option.

Why it's important: Options, as an important type of alternatives, have the potential of adding value to a decision situation. A wise decision maker is alert to that possibility, and actively searches for valuable options.

Uncertainties

Decision making would be easy if we could predict reliably what outcome would follow from the selection of which alternative. To this end decision makers use **forecasts**, or predictions of the future, to guide their choice of alternatives. They attempt to predict the outcome, on all values of interest to the decision maker, associated with each alternative that might be chosen. For example, the decision maker may use forecasts of market size, market share, prices and production costs in order to predict the profits associated with a new product. When the quantities forecasted are uncertain, forecasters can describe their uncertainty about these uncertainties using a **probability distribution**. A probability distribution is a mathematical form for capturing what we know about uncertainties, and how confident we are of what we know. A probability distribution could record, for example, that the decision maker (or his designated expert) believes that there is a 30 percent chance of a product having less than 10 percent market share 2 years after its launch, and a 60 percent chance of the product having less than a 30 percent market share. After assigning probability distributions to each uncertainty, one can examine the uncertainty associated with the outcomes of the decision situation. For example, given probability distributions for price, market share, market size, cost, etc., one can determine a probability distribution for profits.

Frequently in studying a probability distribution one considers its **expected value** (or **mean**), which is the average of the values one would expect to obtain upon sampling from the distribution a large number of times. The expected value weights each possible value by its likelihood of occurring. Another way to summarize a probability distribution is to consider some representative percentiles, for example the 10th-, 50th-, and, 90th percentiles, or "**10-50-90s**" for short. The 10th and 90th percentiles are possible low and high values, respectively, for a given uncertainty, set so that there is a 10 percent chance that the uncertainty, when revealed, will fall below the 10th percentile, and a 10 percent chance that it will fall above the 90th percentile. Similarly, the 50th percentile (or **median**) is that number such that the realized value, when revealed, is equally likely to be above as to be below. Given these percentiles, we can test the **sensitivity** of the decision to the uncertainties. Here we attempt to answer the question whether the decision maker would choose a different alternative if he could know that the uncertainty would have the low (10th percentile) value from the one that he would select if he had knowledge that it would have the high (90th percentile) value. This sort of analysis helps to achieve **clarity of action**. With clarity of action, the decision maker knows what he *should* do, even if he does not know how it will turn out. This is the aim of decision analysis.

Key distinction: ***sensitivity of the decision*** *vs.* ***sensitivity of the outcome***

Example: The profitability of the new product we are developing is sensitive to the market share we achieve. However it may be the case that, as long as we achieve a market share within the range of our 10-50-90s, we would still choose to develop the product. In this case, our development decision is not sensitive to market share.

Why it's important: Everyone wants the outcome to be as good as possible, and in that sense might be interested in knowing to what uncertainties the outcome is sensitive. However, if one is interested in achieving clarity of action, as opposed to predicting the future, one need only be concerned about those uncertainties which would change the decision if we could know in advance how they will turn out.

Outcomes and values

We consider decisions carefully because we care about the outcomes, whose goodness we measure against our values. The most commonly studied and discussed value is **economic value**, which we assume to be measured in dollars. Given a stream of cash flows over time, people often use the **NPV** (net present value) to describe the current value of future cash flows. The NPV is a calculation performed on cash flows over time, allowing one to condense that stream of cash flows into a single number. Decision makers often use the NPV of profits or cash flows as a measure of the

value of a project. The NPV calculation makes use of the **discount rate**, which has several interpretations, but can be thought of as a factor applied to future income to reflect the fact that it is less valuable than income received now. It also reduces the impact of future costs, since costs that can be deferred into the future are preferable to those that must be paid now.

In thinking about the value of a scenario, it is helpful to distinguish between **direct** and **indirect values.** Direct values are cash flows directly related to a project, for example, the profits resulting from the manufacture and sales of a new product. Indirect values are things that the decision maker values that are not likely to show up in accounting statements. For example, a decision maker may experience "pride" or "goodwill" in producing some products and value such an outcome beyond its direct economic value. These indirect values could include costs associated with, for example, laying off workers, or negative impacts on reputation. While some of these indirect values are intangible, others are tangible but difficult to put a number on. For example, increases in "goodwill" associated with one product may result in increased sales of other products though this effect may be hard to estimate.

*Key distinction: **direct** vs. **indirect values***

Example: The direct value of a new product might be the current value of the future cash flow associated with the manufacture and sale of the product. The indirect value might include effects like increased goodwill or strategic advantage that come from having the product but are not directly associated with the manufacture and sale of the product.

Why it's important: Typically, maximizing the NPV associated with a product is one of the decision maker's objectives. The decision maker might, however, assign value in excess of a cash flow based NPV, and that increment might be for what is sometimes termed "strategic value." These indirect sources of value must be included in the NPVs, if one is to think appropriately about values. It is better to put a rough value on these indirect sources (so it can be discussed and evaluated) than to assume they are worth precisely zero.

Often the decision maker will have values other than economic, and in this case he will have to make **trade-offs** between values, which are judgments about how much he is willing to sacrifice on one value in order to receive more of another. For example, in a personal context, a decision maker may need to make a trade off between hours spent at work (something he may wish to minimize so as to maximize the time he spends with his family) and the amount of income he receives.

Risk

As decision makers ponder the possible outcomes of their decisions they often think about **risk**, which is the possibility of an undesirable result. In discussing this, it is convenient to consider the notion of a **risk-neutral** decision maker. Someone who is risk neutral is willing to play the long-run odds when making decisions, and will evaluate alternatives according to their expected values. For example, such a decision maker would be indifferent between receiving $1 for certain and an alternative with equal chances of yielding $0 and $2, since this is the average amount that the alternative would yield if repeated many times. While an insurance company may evaluate individual policies as if it were risk-neutral, for alternatives with substantial risks, decision makers are often **risk averse**, which means that they value alternatives at less than their expected values. To make this definition of value precise, we define the **certain equivalent**, (or certainty equivalent) of an alternative as the amount that the decision maker would be indifferent between (1) having that monetary amount for certain or (2) having the alternative with its uncertain outcome. For example, a risk-averse decision maker might have a certain equivalent of $500,000 for an alternative with equal chances of yielding $0 and $2,000,000, even though the expected value for this alternative is $1,000,000. In thinking about risk aversion, it is important to remember that different decision makers have different attitudes toward risk. While this gamble with equal chances of yielding $0 and $2,000,000 may be very risky for me, a billionaire or a big company may not view these stakes as large and may have a certain equivalent close to the expected value.

Decisions where risk aversion holds can be analyzed using a **utility function**, which encodes a decision maker's attitude toward risk taking in mathematical form by relating the decision maker's satisfaction with the outcome (or "utility" associated with the outcome) to the monetary value of the outcome itself. These utility functions can be indexed by their **risk tolerance**, which is a technical term describing the decision maker's attitude toward risk. The greater the decision maker's risk tolerance, the closer the certain equivalent of a gamble will be to its expected value. The risk tolerance is a mathematical quantity that describes the decision maker's attitude towards risk; it is *not* the

maximum amount that the decision maker can afford to lose, though generally decision makers with greater wealth will have larger risk tolerances. The decision maker needs to think about his risk tolerance only in cases where the stakes are large and he is not comfortable basing his decision on the expected monetary value.

> *Key distinction:* ***certain equivalent*** *vs.* ***expected NPV***
>
> *Example: The certain equivalent for a risky new product is the smallest sum of money for which the decision maker would be willing to sell rights to that product. The expected NPV for the product is the hypothetical average NPV from numerous independent launches of identical projects.*
>
> *Why it's important: Most projects cannot be repeated and even if they could, when the stakes are large, most decision makers value gambles at less than their expected values. Precisely how much less than their expected value depends on the decision maker's attitude towards risk. This attitude towards risk varies from decision maker to decision maker and, even for a specific decision maker, may vary over time.*

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Author's Note

This short narrative is intended to provide, in non-technical terms and in a readable way, definitions of the words most commonly used in a decision making context. I have written this because I have found that these words are frequently used incorrectly. In a sense, misunderstanding language is more insidious than not understanding it at all, in that it distorts meaning. Distortion of meaning, with its attendant confusion of thought, deters us from the goal of good decision making, which is clarity of action, the right action. I hope you can read this in 10 minutes or less and benefit from it.

Several colleagues have contributed appreciably to the quality of this document, and I would like specifically to mention Bob Clemen, Don Keefer, Craig Kirkwood, Bob Nau, and Jim Smith. The reader has no way to gauge their contribution, but I do. Thanks, Dr. Tom Spradlin, Confident Choices .

About the Author

Tom Spradlin started his career in the pharmaceutical industry in the International Medical Department of C.H. Boehringer Sohn in Ingelheim, Germany in 1969. After completing his Ph.D. degree in Biostatistics at the Johns Hopkins University in 1976 he joined the statistics department of Eli Lilly and Company in Indianapolis, Indiana. He spent 13 years in that position, serving as principal statistician on many regulatory submissions, particularly in anti-infectives and insulin products.

After three years as a project manager in Lilly's International Medical component, Tom became interested in decision consulting, and was one of the charter members of Lilly's Decision Sciences department. In his ten years in that role he consulted on a wide variety of decision situations, especially in research strategy and operations, litigation, manufacturing, and business development.

Tom retired from Lilly in 2001 and formed Confident Choices (www.confidentchoices.com), a consultancy dedicated to assisting clients facing difficult decisions to make the right choice efficiently and with confidence. Tom is a former member of the Council of the Decision Analysis Society of the Institute for Operations Research and Management Science, and is a founder of the Decision Analysis Affinity Group, a collection of industrial decision consultants from the USA, Canada, Europe, and Japan.

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