Part 1 | Decision-Making in IP Management

Chapter 1 | Introduction to Decision-Making

Decision-making and IP management

When it comes to IP management, IP managers are continuously confronted with decisions. They have to evaluate options, assess future developments, and anticipate the consequences of their decisions. Rational or sound decision-making is considered to be a primary function of management. Here are some examples of typical IP management questions and decision issues (see Table 1).

IP management related questions	Related decisions (examples)
Which are the IP department's most important tasks?	▪ IP administration primarily by humans or by software ▪ Integration of IP management and other corporate functions ▪ Degree of linkage of IP management to other corporate functions ▪ "Make or buy" when establishing new IP ▪ …
Which are the criteria for measuring the success of IP strategy implementation?	▪ Explicit or implicit verbalization of an IP strategy ▪ Target system pursued ▪ Accepted effort for the assessment of parameters ▪ Further use of results (e.g. budget adjustment, incentives) ▪ …
How are IP related costs / expenses controlled?	▪ Controlling by setting budget restrictions for IP management or by assessing cost/benefit ratio ▪ Fixing the budget ▪ Budgeting on a corporate, divisional or product level ▪ …
How shall IP infringements be detected?	▪ Willingness to enforce IP against third parties ▪ Company functions that should be involved in infringement detection (and are frequently trained) ▪ Observed objects (online offers, marketing materials etc.) ▪ Observed enterprises ▪ …
Is the IP portfolio frequently adjusted?	▪ Limitation of the IP rights' life time (to a time span below maximum life time) ▪ Use of static criteria (e.g. predefined life time), valuation criteria or decision on a by-case basis (e.g. in a regular meeting) ▪ Degree / aim of adjustment (maximum budget, no obsolete IP etc.) ▪ …

Table 1: Example of IP management related questions and decisions.

Decision-making is an integral part of modern management. The ability to make effective decisions, to design comprehensible decision processes, and to understand and manage risk is crucial for IP managers. Decision-making is about knowing and understanding all alternatives, it is about uncertainty about the future, it is about consequences, it is linked to interpersonal issues and potential conflicts, and due to the rising complexity of modern organizations and businesses, it is about complexity.

Every manager takes hundreds of decisions - subconsciously or consciously - as a key component of their managerial duties. Decisions play an important role as they determine both organizational and managerial activities. A management decision can be defined as a

course of action purposely chosen from a set of alternatives to achieve organizational or managerial objectives or goals. The decision-making process is a continous and indispensable component of managing any organization or business acitivities. Decisions are made to sustain the activities of all business activities and organizational functioning.

Decisions are made at every level of management to ensure organizational or business goals are achieved. What is more, decisions make for one of the core functional values that every organization adopts and implements to ensure optimum growth and manageability in terms of the services and/or products offered.

Decision-making in everyday life

Empirical data suggest that an average person makes around 35,000 choices per day. Assuming that most people spend around seven hours a day sleeping and thus choice-free, that makes roughly 2,000 decisions per hour or one decision every two seconds. Decision-making is a process that plays an important role in our daily lives. Some decisions are not that important, whereas other important decisions, when carefully executed, can change the course of our lives. The process of decision-making involves making a choice among different courses of action and entails a cycle of activities and events that begins with identifying a problem and ends with evaluating implemented solutions. Therefore, it is useful to conceptualize decision-making as a process.

A process is a sequence of interdependent and linked procedures or steps which, at every stage, consume one or more resources such as employee time, energy, and money, to convert inputs like data or material into outputs. The process of decision-making can be categorized into programmed (routine) or non-programmed (strategic) decision-making. A programmed decision is one that people use in their everyday lives and apply to recurring, routine problems which are often anticipated. Here, people use information from past experiences to solve problems they are familiar with. Non-programmed decisions usually solve problems that are unanticipated. They occur less often and rely on personal attributes such as intuition, creativity, experience, judgment, etc.

Here, people must identify the problem and act after assessing plausible alternatives. It usually requires creativity, which helps in creating and evaluating alternatives and readiness to take risk, which allows people to choose an alternative.

Importance of decision-making

It is commonly accepted that management is basically a decision-making process. In other words, "the manager is the one who makes the decision". It is argued that only through making decisions, an organization can accomplish its short-term and long-term goals. A decision is an act of selecting or choosing one action from several alternatives.

Decision-making can be defined as the process of selecting a right and effective course of action from two or more alternatives for the purpose of achieving a desired result. Decision making is the essence of management.

The essence of management consists of four activities:

1) Planning, including identifying goals, objectives, methods, resources needed to carry out methods, responsibilities, and completion dates. Examples of planning include strategic planning, business planning, project planning, staff planning, advertising and promotions planning, etc.
2) Organizing resources to achieve the goals in an optimal fashion. Examples are organizing new departments, human resources, office and file systems, re-organizing businesses, etc.
3) Leading, including setting direction for the organization, groups, and individuals, as well as influencing people to follow that direction. Examples are establishing strategic direction (vision, values, mission, and/or goals) and championing methods of organizational performance management to pursue that direction.
4) Controlling or coordinating the organization's systems, processes, and structures to reach effectively and efficiently reach goals and objectives. This includes the ongoing collection of feedback, and the corresponding monitoring and adjustment of systems, processes, and structures. Examples include the use of financial controls, policies, and procedures, performance management processes, measures to avoid risks, etc.

According to P. F. Drucker – "What¬ever a manager does he does through making decisions." All matters relating to

- planning,
- organizing,
- leading,
- co-ordination, and
- control

are settled by the managers through decisions which are executed by the operators of the enterprise. Objectives, goals, strate¬gies, policies, and organizational designs are all to be decided upon in order to regulate the performance of the business.

In the words of typical management textbooks: "A decision is an act of choice wherein an executive forms a conclusion about what must be done in a given situation. A decision represents behavior chosen from a number of alternatives." The definition of decision-making has three different but interrelated implications.

These are as follows:

1) When managers make decisions, they exercise choice. They decide what to do on the basis of conscious and deliberate logic or judgement.
2) When making a decision, managers are faced with alternatives. An organization does not require a wise manager to reach a decision when there are no other possible choices. It requires wisdom and experience to evaluate several alternatives and select the best one.
3) When taking a decision, managers have a purpose. They propose and analyze the alternative courses of action, and finally make a choice that is likely to steer the organization in the direction of its goals:
    a. In fact, the whole planning process constantly sees managers in a series of decision-making situations. The quality of managerial decisions largely affects the effectiveness of the plans made by them.
    b. In organizing processes, managers must decide upon structures, division of work, the nature of responsibilities and relationships, the procedures of establishing such responsibilities and relationships, and so on.
    c. In terms of co-ordination, decision-making is essential for providing unity of action. When it comes to controlling, it helps to make decisions on how to define the standard, how to rectify deviations from the standard, how to establish principles, how to issue instructions, and so on.

The ability to make good decisions is the key to successful managerial performance. The managers of most profit-oriented firms are constantly required to take a wide range of important decisions in the areas of pricing, product choice, cost control, advertising, capital investments, dividend policy, personnel matters, etc. In IP management, for example, the development, execution, and implementation of strategies have to be decided, portfolio decisions have to be made, infringement cases have to be detected and enforced, etc.

Decision making is also a criterion to determine whether or not a person is in a management role. If they participate in decision-making, they are regarded as management staff.

In the words of George Terry: "If there is one universal mark of a manager, it is decision-making."

In any business, whether large or small, conditions are never static but visibly dynamic. The old order is constantly giving way to something new, whether in terms of personnel or in unforeseen contingencies. Ever-changing conditions are becoming the rule. Such a situation calls for actions that involve decision-making.

So, decision-making is firmly connected to management functions and both are bound up together inseparably. When a manager plans or organizes, orders or advises, approves or disapproves anything, he will have to move with the process of decision-making. In all managerial functions, decision-making is an indispensable accompaniment.

Rational decision-making

Rational decision-making brings a structured or reasonable thought process to the act of deciding. The choice to make rational decisions enables us to support the decision-maker by sharing open and specific knowledge with them. This can be very important when making high-value decisions that can benefit from the use of tools, processes, or the knowledge of experts.

Choosing rationally is often characterized by the following:

- Decision-making will follow a process or orderly path from problem to solution.
- There is a single best or optimal outcome. Rational decisions seek to optimize or maximize utility or value.
- The chosen solution will be in agreement with the preferences and beliefs of the decision-maker.
- The rational choice will satisfy conditions of logical consistency and deductive completeness.
- Decision-making will be objective, unbiased, and based on facts.
- Information is gathered for analysis during the decision-making process.
- Future consequences are considered for each decision alternative.
- Structured questions are used to promote a broad and deep analysis of the situation or problem requiring a solution.
- Risk and uncertainty are addressed with mathematically sound approaches.
- In the ideal case, all rational decision-makers would come to the same conclusion when presented with the same set of sufficient information for the decision being made. This would suggest that collaborative decision-making often employs a rational decision-making process.

Problems and limitations with choosing rationally

Most of the issues and limitations associated with rational choice result from falling short of the ideal prescribed in the full rational decision-making model. The following three areas generate much of the concern:

Limits of human capabilities - The limits of our human ability to gather, process, and understand all the information needed to optimize a decision outcome make it impractical to meet the ideal, except in very constrained or simple situations. There are limits to managers' ability to formulate and solve very complex problems. The desire to optimize is also limited, and managers will usually "satisfice", or be content with acceptable solutions when confronted with obstacles.

Limits on information and knowledge - The rational choice model assumes managers should or can gather sufficient information in terms of quantity, quality, accuracy, and integrity. It also assumes that managers have access to the required knowledge of the cause and effect

relationships that are important to evaluate alternative solutions, particularly with respect to projecting future consequences.

Limits in time - Search for the optimum solution will generate a delay that could negatively impact the benefits of the chosen alternative. In essence, if the decision alternatives are not properly discounted for changes due to decision timing, the chosen alternative may not be optimal.

More on decision-making models

As with any ideal, additional models have been developed to address the problems with realizing the full rational model. The Bounded Rationality model acknowledges our cognitive and environmental limits, and suggests that we act rationally within these constraints. Many decision-making theories are a result of looking at the consequences of bounded rationality.

Rational ignorance takes a similar approach to looking at the cost of gathering information. In this model, it is suggested that if the cost of acquiring information exceeds the benefits that can be derived from the information, it is rational to remain ignorant. This is in alignment with the concept of using decision value to limit the decision effort, ensuring an appropriate return from using a rational decision-making process.

The benefits of rational choice

Within the limitations described above, making rational choices can provide a number of benefits that include:

- Addressing complex decisions by breaking them down
- Characterizing decision problems and goals to ensure all needs and desire are addressed
- Being aided by structured techniques, mathematics, and computers
- Ongoing improvement when codified in a process, procedure, or program
- A long list of decision-making techniques and tools with proven usefulness
- A growing capability to analyze and access the information that can improve guidance based on facts

Chapter 2 | Decision Theory and Cognitive Biases

Decision theory: normative, descriptive, and prescriptive theories

Decision theory is a truly interdisciplinary challenge to which philosophers, economists, psychologist, computer scientists, and statisticians contribute their respective expertise. Even if their perspectives on decisions differ, experts from all disciplines share a number of basic concepts and distinctions. One of these common points is to distinguish descriptive, normative, and prescriptive decision theory.

The origins of modern decision theory are found in Bernoulli's (1783) observation that the subjective value, i.e. utility ("Value, valuation and object of valuation" -> IP-Valuation (I): Part 3), of money diminishes as the total amount of money increases. His second observation was that the utility from gaining an additional dollar would decrease with wealth; he argued that "one thousand ducats is more significant to a pauper than to a rich man though both gain the same amount". He claimed that the marginal utility of wealth decreases as wealth increases, a view that is at the core of most conventional economic theory today. Technically, diminishing marginal utility implies that utility increases as wealth increases, and at a declining rate. Another way of presenting this notion is to graph total utility against wealth.

However, utility remained a qualitative concept until the seminal work of von Neumann and Morgenstern (1947). They generalized Bernoulli's concept of utility (which was limited to the outcome of wealth -> see ("Economics of intangible assets" -> IP-Valuation (I): Part 2)), developed lotteries to measure it, formulated normative axioms and formalized the combination into an econo-mathematical structure called utility theory. Since then, the volume of research on decision-making has exploded.

Descriptive decision theories seek to explain and predict how people make decisions. This is an empirical discipline, stemming from experimental psychology. The studies of Nobel Prize winner Daniel Kahneman about behavioral psychology and decision-making, for instance, are part of descriptive decision theory. Kahneman explains the two systems that drive the way we make decisions. System 1 is fast, intuitive, and emotional; System 2 is slower, more deliberative, and more logical. Kahneman exposes the extraordinary capabilities, and the faults and biases of fast thinking, and reveals the pervasive influence of intuitive impressions on our thoughts and behavior. The impact of loss aversion and overconfidence on corporate strategies, the difficulties of predicting what will create company success in the future, the challenges of properly framing risks at work, the profound effect of cognitive biases on everything from playing the stock market to planning the next patent application — each of these can be understood only by knowing how the two systems work together in shaping our judgments and decisions.

Normative theories seek to yield prescriptions about what decision-makers are traditionally required to do. Therefore, descriptive and normative decision theory are two separate fields

of inquiry. In the prescriptive tradition, experts try to analyze how to make decisions in the best and most rational way, and the canonical way of decision-making will be explained in the following chapters.

The following table 2 should clarify the different schools of thought in relation to decision-making theory:

	normative	**descriptive**	**prescriptive**
focus	how people should decide with logical consistency	how and why people decide the way they do	help people make good decisions prepare people to decide
criterion	theoretical adequacy	empirical validity	efficacy and usefulness
scope	all decisions	classes of decisions tested	specific decisions for specific problems
theoretical foundations	utility theory axioms	cognitive sciences psychology about beliefs and preferences	normative and descriptive theories decision analysis axioms
operational focus	analysis of alternatives determining preferences	prevention of systematic human errors in inference and decision-making	processes and procedures end-end decision life-cycle
judges	theoretical sages	experimental researchers	applied analysts

Table 2: Overview of the normative, descriptive and prescriptive decision theory schools.

Decision theory and uncertainty about the future

Decision theory provides a rational framework for choosing between alternative courses of action when the consequences resulting from this choice are imperfectly known. The necessity of making decisions in the face of uncertainty is an integral part of IP management. Managers must act without knowing the consequences that will result from the action. This uncomfortable situation is particularly acute for the IP managers who must make far-reaching decisions on complex issues in a rapidly changing technological, economical, and legal environment. Uncertainty appears to be the dominant consideration in many systems as well as in decisions that managers must make for their careers. Confronting uncertainty is not easy – people have a natural aversion to uncertainty. The issue here is the challenge of forecasting the future.

In decision theory, everyday terms such as risk, ignorance, and uncertainty are used as technical terms with precise meanings. In decisions under risk, the decision-maker knows the probability of the possible outcomes, whereas in decisions under ignorance, the

probabilities are either unknown or non-existent. Uncertainty is used either as a synonym for ignorance, or as a broader term referring to both risk and ignorance.

Although decisions under ignorance are based on less information than decision under risk, it does not necessarily mean that decisions under ignorance must therefore be more difficult to make. An IP manager knows, for example, that there is a one in three chance that a granted patent survives a nullity case. But what is the probability for their specific case? There are license payments for standard patents and the question is what is the probability that the next licensee will pay the same license fee. These kinds of extrapolations are, one the one hand, based on observable probabilities, but on the other hand, they are transferred empirical data from related or close, but not identical evidence.

Much current scientific effort goes into forecasting future economic and technological developments. If these predictions are assumed to be completely accurate, the uncertainty in many systemic decisions is eliminated. The outcome resulting from a possible course of action may be presumed to be known. Decision-making becomes an optimization problem, and techniques such as mathematical programming may be used to obtain a solution. Such problems may be difficult to solve, but this difficulty should not obscure the fact that they represent the limiting case of perfect predictions. It is often tempting to assume perfect predictions, but in doing so, managers may be eliminating the most important feature of the problem. Especially when it comes to IP valuation, managers should not just include the predictions themselves in their analysis, but also a measure of the confidence they have in these predictions. A formal theory of decision-making and valuation must take uncertainty and risk as its departure point, and regard precise knowledge of outcomes as a limiting special case.

Good decisions and good outcomes

Managers should be able to distinguish between good decisions and good outcomes. Everybody is familiar with situations in which careful management and extensive planning produced poor results, while a disorganized and badly managed competitor achieved spectacular success. As an extreme example, place yourself in the position of the company president who has discovered that a valuable and trusted subordinate whose past judgment had proved unfailingly accurate based his decisions upon the advice of a fortune teller. Would you promote this man or fire him? The answer of course, is to fire him and hire the fortune teller as a consultant. The availability of such a clairvoyant to provide perfect information would make decision theory unnecessary. But managers should not confuse the two. Decision theory and, based on that, valuation, is not a substitute for the fortune teller. It is rather a procedure that takes account of all available information to give management the best possible logical decision. It will minimize the consequences of achieving an unfavorable outcome, but managers cannot expect the theory to shield people or companies from all "bad luck". The best protection managers have against a bad outcome is a good decision.

Decision theory is often regarded as a formalization of common sense. Mathematics provides an unambiguous language in which a decision and valuation problem may be represented. There are two dimensions to this representation which we would like to describe here: value, by means of utility theory, and information, by means of probability theory. In this representation, the large and manifold problems of systems analysis and inherently complex valuation scenarios becomes conceptually equivalent to simple problems in daily life that people solve with "common sense".

Heuristics, cognitive biases & decision making

The brain is an incredibly effective decision-making machine. Hundreds of thousands of years of evolution have created a lean machine with many inbuilt shortcuts to enable humans to function effectively in complex environments. The brain uses heuristics to draw conclusions about the world with minimal effort. While heuristics are indeed useful, they can at times lead to the wrong conclusions being drawn. A lot of the time, these false conclusions are not harmful, however, when it comes to complex and important decisions, these cognitive schemas or shortcuts can be misleading and dangerous.

Heuristics are mental shortcuts used to quickly solve a problem, decide, or answer a question. The brain uses prior data to generate a quick response so that it does not have to spend time developing a new solution every time a new situation arises. This saves time when having to draw conclusions about large amounts of information and can be extremely useful in quickly allowing us to make sense of complex environments and situations. Availability heuristics are used, for instance, to assess the probabilities of events based on other similar occurrences that are easily recalled. The easier examples come to mind; the more weight people give to them. Availability heuristics are useful when judging the frequency and probability of events without spending time thinking in-depth about the probability.

However useful heuristics are, they can also fail at making correct assumptions about the world. When heuristics 'fail', the result is a cognitive bias: drawing a false conclusion based on prior data. One of the most common heuristics are availability heuristics, where it is easier to recall events with greater consequence or impact. For example, after multiple news reports about shark sightings, you are more afraid of being bitten by a shark when swimming by the beach, compared to something more mundane such as having a car crash on the way to the beach. You are much more likely to have a car crash than be bitten by a shark, but the focus is placed on the shark.

Examples for such biases, especially in innovation projects, include:

- Confirmation bias: People believe what they want to believe by favoring information that confirms preexisting beliefs or preconceptions. This results in looking for creative solutions that confirm their beliefs rather than challenge them, causing aversity to new possibilities.

- Conformity bias: Choices of mass populations influence how people think, even if against independent personal judgments. This can result in poor decision-making and lead to groupthink, which is particularly detrimental to creativity as outside opinions can become suppressed leading to self-censorship and loss of independent thought.
- Authority bias: Favoring opinions and ideas of authority figures within innovation teams. This means that innovative ideas coming from senior team members trump or improve all others, even if other concepts, ideas, and inputs could be more creative and relevant to solving the problem.
- Loss aversion bias: Sticking to a decision once it has been made rather than taking risks due to the fear of losing what managers gained in starting something and wishing to see it finished. People also attach more value to something once we have made an emotional investment in it. A consequence of effort, time, and energy put into creative thinking, team members can become biased and become emotionally attached to their outcomes.
- False causality bias: Citing sequential events as evidence that a first event caused a second one. This can occur within the empathize phase of the design thinking approach where IP managers are intentionally seeking confirmation of causality between what people say vs. what they do. This can lead to the wrong problems or needs being taken forward to solve.
- Action bias: When faced with ambiguity (creative fuzzy-front-end), preferring not to take any action without prior analysis, even if it is counterproductive: "I have to do something, even if I don't know what to do". Team members can feel that they need to act regardless of whether or not it is a good idea. This can be an issue when under time pressure in strict design sprint workshops for example.
- Self-serving bias: Favoring decisions that enhance self-esteem. This results in attributing positive events to oneself and conversely negative events as blame on oneself. In the context of innovation workshops, this can mean that decisions made can be loaded with personal agendas rather than a customer and business logic for the company.
- Framing bias: Being influenced by the way in which information is presented rather than by the information itself. Managers witness this all the time, particularly when developing prototypes for pitching as well as when presenting polished slides. People will avoid risk if presented well and seek risk if presented poorly, meaning that the decision-making logic can easily be skewed.
- Ambiguity bias: Favoring options with a more predictable outcome over those with less predictable outcomes. This bias has dire impacts on innovation outcomes, because the process is a fundamentally risky and unknown process. If team members subconsciously favor known knowns, the team will most likely follow known knowns and previously trodden paths.
- Strategic misrepresentation: Knowingly understating the costs and overstating the benefits. When developing innovative concepts, ballpark figures, and business model prototypes, teams are prone to understating the true costs and overstating the likely benefits in order to get a project approved. Over-optimism is then spotted and challenged by managers assessing how truly innovative team outcomes are.

- Bandwagon bias: A commonly known bias favoring ideas already adopted by others. This is especially influential when linked to authority bias. The bandwagon effect is a common occurrence one can see in workshops. The rate and speed at which ideas are adopted by others can significantly influence the likelihood of those ideas and concepts being selected by the group and taken forward.
- Projection bias: From behavioral economics, over-predicting future tastes or preferences will match current tastes or preferences. This bias is particularly influential as new innovations are conceived in the now and are projected into the future when they enter markets resulting in over-appreciation of consumer preferences.
- Pro-innovation bias: Innovations should be adopted by all members of society (regardless of the wider needs) and are pushed-out and accepted regardless. Novelty and 'newness' are seen as inherently good, regardless of potential negative impacts (inequality, elitism, environmental damage etc.) resulting in new ideas and concepts generated being judged through somewhat rose-tinted spectacles.
- Anchoring bias: Being influenced by information that is already known or that is presented for the first time. This causes pre-loaded and determined tunnel vision and influences final decision-making. The impact is highly significant for creative thinking and outcomes.
- Status quo bias: Favoring the current situation or status quo and maintaining it due to loss aversion (or fear of losing it) and do nothing as a result. This is a subtle bias on an emotional level that makes managers reduce risk and prefer what is familiar or "the way we do things around here" as it is known. It has severe consequences when seeking out new ways to creatively solve needs and problems.
- Feature positive effect (closely linked to optimism bias): Due to limited time or resources, managers tend to focus on the 'good' benefits whilst ignoring negative effects, even when the negative effects are significant. This is influential when deep-diving into specific new feature sets for new concepts (especially when coupled with loss aversion bias), because it means that teams will overlook missing information, especially when it is outside expertise resulting in ideas with critical flaws being taken forward.

Chapter 3 | Decision Process

The phenomenon of "decidophobia"

Decision-making could be defined as the study of identifying and choosing from alternatives the option that best suits a purpose. In the earlier parts of this course, we regarded it as a cognitive study as it involves mental and logical reasoning. In decision-making, there are various alternatives worth considering. However, the focus is not on the number of different alternatives, but rather on identifying all available alternatives, and choosing the one with the highest probability of success or the one that is most suitable for achieving specific goals or objectives. Decision-making is a process that reduces uncertainty to a considerable extent. In most decisions, uncertainty is reduced rather than being eliminated. Only in a few instances, decisions are made with absolute certainty. This implies that most decisions and valuations involve a certain degree of risk. If there was no uncertainty, there would be no decision and no valuation as managers would just act and expect a fixed result. The fear of making important decisions is a well-known phenomenon called "decidophobia", as proclaimed by Walter Kaufmann at Princeton University in 1973. Wherever we see a successful business, someone once made a courageous decision. The fear of making wrong decisions runs in the veins of all good leaders and managers, but the ability to make the right decision despite that fear is what makes them successful.

Decision types

There are various types of decisions, which can be categorized in three different groups according to their characteristics:

Decisions on Whether: These are decisions involving a yes or a no. Examples include a project manager considering to hire additional team members or an IP manager wondering whether or not to file a patent application. The decision-maker can only go for one of the two options, there is no middle way when it comes to making such a decision, and a decision has to be made before other alternatives come up.

Decisions on Which: This type of decision involves making a choice from two or more alternatives, choosing the one with the highest probability of success or the one that best fits the circumstances. An example of such a decision would be investors deciding on what brand or product to invest in from various options.

Conditional or Contingent decisions: These are decisions which are pre-determined by certain conditions being met. This makes it easier for the decision-maker to take action once those conditions are met, or, to quote a certain IP manager: "I decided to file the patent if we are awarded the budget".

What are the principles used for making decisions?

The critical task is to identify values, uncertainties and other factors that might influence the decision. Decisions can be made under conditions of certainty (each alternative leads to a goal or consequence), risk (each alternative has one or more consequences and the probability of each is known), and uncertainity (each alternative leads to one or more consequences with unknown probabilities). There are different types of decision theories that have been implemented in practice:

Causal decision theory: This is an old theory that is still in use today. This theory relies on the principle of rational choice, which implies that the outcome of managerial choice is a consequence of the decision.

Evidential decision theory: In contrast to causal decision theory, this theory holds that the best option is to choose the alternative with the best outcome, which may be considered irrational thinking.

Game theory: This is the mathematical study of strategic decision-making. It is considered to be an interactive decision theory as it takes into consideration the conflict of cooperation between intelligent rational decision-makers.

Bayesian theory: This is a probability theory used in decision-making. Bayesian is regarded to be an extension of logic that enables reasoning with either a true or a false state. The above theories can all be regarded as mathematical theories of decision-making. Decision-making theories can also be categorized by analyzing the approach and procedure used in making a decision.

Which approaches to decision-making are there?

Authoritarian: The manager or team leader makes a decision based on their own knowledge or experience, and communicates their decision to the group and awaits their acceptance.

Group: The group tends to make decisions together by analyzing the different alternatives that fit their objective. Some studies have come to the conclusion that, in an Authoritarian approach, the leader spends five minutes making a decision, thirty minutes communicating their decision, and another 30 minutes for the group to accept that decision, while, in a Group approach, the group spends 30 minutes analyzing and deciding on the best option. Therefore, the Group approach is driven by greater motivation as group members tend to appreciate ideas they have come up with themselves and will work towards achieving goals set by themselves with greater zeal than when decisions are taken on their behalf.

Automating System: This refers to a compter system that automates significant (or all) parts of an administrative decision-making process. The primary feature of this system is its ability to build and automate administrative decisions into a computer system using a certain logic. Automated systems may range from conventional information technology systems through

to more complex systems such as 'expert tools', 'business rules engines', 'rule-based engines', 'decision-support tools', and instruments based on artificial intelligence. Automated systems are a developing approach to decision-making, as managers find it easier to make unbiased decisions once the right criteria have been entered.

Decision-making framework

For a decision-making framework, it is important to distinguish between an object and a subject system (see Figure 1). The object system comprises the decision environment, which includes exogenous factors such as legal frameworks, markets, IPR systems, technologies, competitors, IPR portfolios, outputs, production functions, etc. Based on the decision environment, information about the decisions and the influencing factors can be gathered. This information flows into the subjective system of the decision-maker. The decision-maker has to take into account the endogenous objectives of the business, including business strategy, market position, IPR strategy, etc. The decision-maker will follow a subjective decision process which leads to the decision, which will be implemented and change the decision environment.

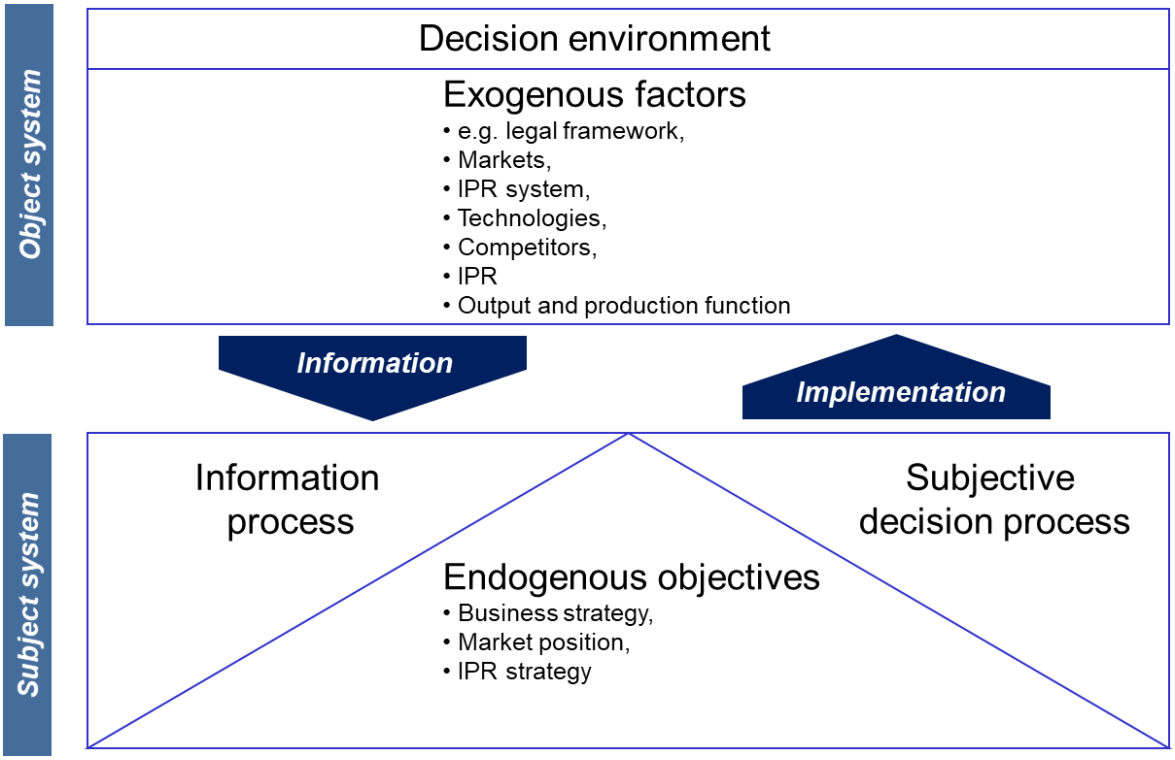

Figure 1: Overview of a decision-making framework with the subject and object system.

Decision-making procedure

The decision-making process consists of distinct stages. Step one is to identify the problem. This stage involves understanding with absolute clarity what the issue is and what type of decision needs to be made. The first thing managers must do is name the underlying problem to be solved, clearly stating the desired outcome of the corresponding decision. A

problem can be defined as a discrepancy between an existing and a desired state of affairs. The accurate definition of the problem affects all the steps that follow. If the problem is inaccurately defined, every step in the decision-making process will be based on an incorrect starting point. This is also true for valuation tasks. Choosing the right starting point is critical for the entire process that follows. Important considerations in this step are:

- Making sure it is a problem and not just a symptom of a problem
- Making sure problem identification is objective
- Discrepancies can be found by comparing current results with norms, rules, and standards
- Managers are unlikely to characterize a discrepancy as a problem, if they perceive that they do not have the authority, information- or resources needed to act on it

The second step encompasses the diagnosis of the problem and the identification of decision criteria. At this stage, managers will perform an extensive analysis of the issue and really delve into the details. In addition, it is important to allocate different weights to the different criteria. The criteria are not all equally important, so the decision-maker must weight the items in order to give them correct priority in their decision. It is necessary to classify the problem in order to know who must take the decision and who must be informed about the decision taken. Important considerations in this step are:

- Exploiting the issue from different perspectives – for example by using the diverse expertise of a decision-making team
- Asking the relevant what, why, when, who, where, and how questions in order to dissect the issue to an appropriate level
- Refining the decision statement based on the analysis

The third step encompasses the discovery of alternative courses of action. In this step of the decision-making process, managers will list all possible and desirable alternatives. Here, it is important not to have any restrictions so as to consider more than just the very obvious options. Experience and creative skills are necessary to come up with alternatives which may look irrelevant but possible. In this step, it is necessary to perform adequate research in order to establish the necessary facts that would aid in solving the problem.

If there are no alternatives, there is no decision to make. Where there are alternatives, there has to be a degree of uncertainty as to which alternative is best for a required decision. Decision-making and uncertainty are directly correlated and inevitably linked together. This also holds true for valuation, which is a specific kind of evaluation of alternatives.

Step four is about weighting the evidence. Managers have to draw on information to imagine what it would be like if they carried through each of the alternatives to the end. They have to evaluate whether the need identified in Step 1 would be met or resolved by using each alternative. As managers go through this difficult internal process, they will begin to favor certain alternatives, i.e. those that seem to have a higher potential for reaching the

goal. Finally, they place the alternatives in a priority order, based upon their own value system. Important considerations in this step are:

- Finding out the advantages and disadvantages of each option
- Filtering out the options that seem impossible or do not serve the given purpose
- Rating each option with a numerical digit to support the filtering process

If a decision is required, personal preferences and values play a significant part in the decision-making process, and preferences are affected by innate personal bias and the social context managers are making their decisions in.

Step five is about selecting the best alternatives. This is the step where the analysis comes to an appropriate decision. This includes selecting the alternatives which appear to be best suited for the situation. Choosing the best alternative is the most critical point in decision-making.

Step six encompasses implementation and follow-up action. In this final step, managers should consider the results of their decision and evaluate whether it has resolved the need identified in Step 1.

Overview of the decision-making process

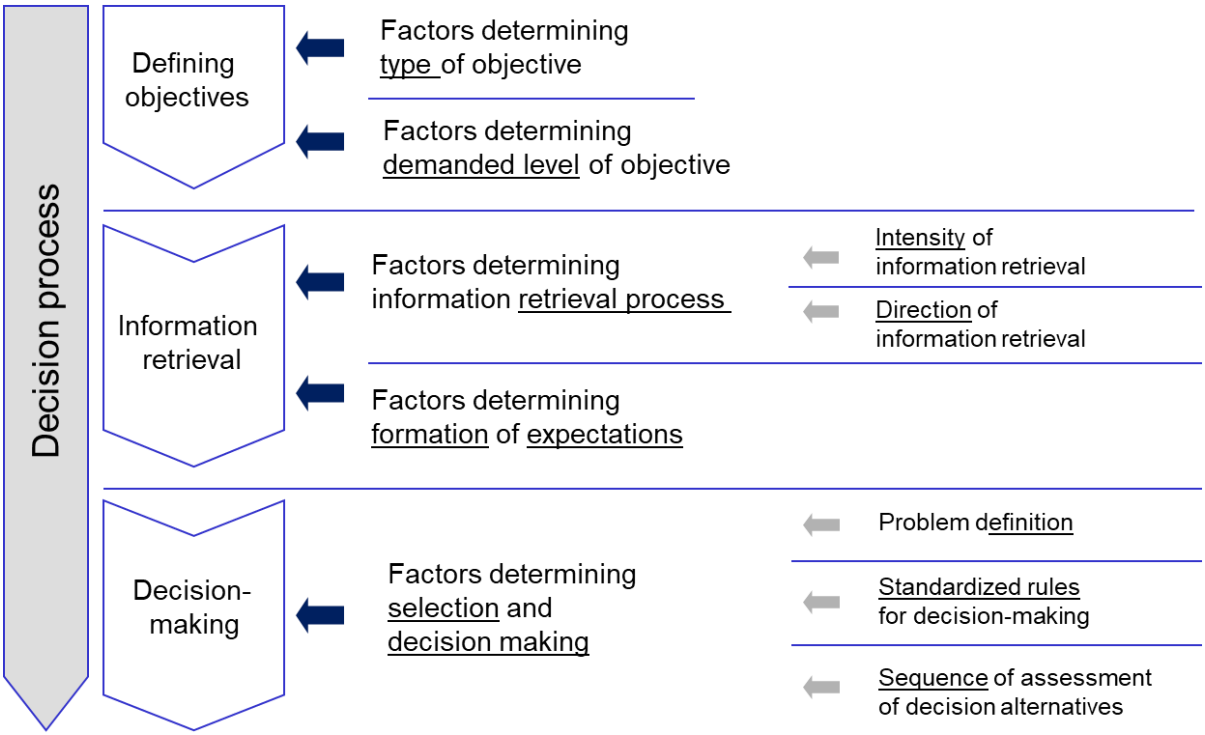

Figure 2: Overview of the decision-making process. Source: *Cyert, R. M. / March, J. G. (1963): A behavioral theory of the firm, Englewoods Cliffs.*

A generic decision-making process can be reduced to three phases (see Figure 2). Phase one involves defining the objectives. The main influencing factors here are the type of objective and the demanded level of objectives. During the second phase, the information retrieval stage, the main influencing factors are the intensity and direction of information retrieval, as well as the corresponding formation of expectation. Finally, decision-making is influenced by factors determining selection, including problem definition, standardized rules for decision-making, and the sequence of assessing decision alternatives.

Information in decision-making and valuation

For every uncertainty, there is information that has the potential to reduce it. Without information, managers make a decision and then find out what happens. With information, they find out what will happen and then decide what to do. Like valuation, decision-making is predominantly an information issue. The better and more comprehensive the information, the better the decision and valuation when all other factors are static.

However, managers rarely if ever have enough information; as Carl von Clausewitz wrote more than 100 years ago: "War is the realm of uncertainty; three quarters of the factors on which action in war is based are wrapped in a fog of greater or lesser uncertainty…. The commander must work in a medium which his eyes cannot see; which his best deductive powers cannot always fathom; and with which, because of constant changes, he can rarely become familiar." When substituting 'war' for 'business', the sentiment remains true for business decision-making today.

It is important to see that information has no value at all unless it has the potential to change decisions! What is critical is not the amount of information at hand, but having the key elements of information available in a useful form when needed, in order to improve our awareness of the situation and our ability to act. Once the best possible (but typically inadequate) information has been gathered, decisions need to be made, and usually no such decision will lead to the least beneficial outcome.

In addition, the quality of the information being assessed is taken into account, provided, and used. In practice, no information is complete or perfect. Before making use of any information, the decision-maker has to evaluate the reliability and accuracy of the information, and look for any vested interests or bias on the part of the people developing the information. Everyone is biased and almost everyone involved in information gathering and development has an interest in the information they have helped assemble, so the question has to be what effect these influences may have.

Chapter 4 | Descriptive Decision Theory

Rational decisions, rationality, and neoclassical economics

Classical theories of choice in organizations and management refer to decision-making as rational choices on the basis of expectations about the consequences of action for prior objectives, and organizational forms as instruments for making those choices. Rational choice theory is an umbrella term for a variety of models explaining social phenomena as outcomes of individual action that cannot be classified as rational. Rational behavior is behavior that is suitable for realizing specific goals, taking into account the limitations imposed by the situation. The key elements of all rational choice explanations are:

- individual preferences,
- beliefs,
- and constraints.

Preferences denote the positive or negative expectations individuals attach to the possible outcomes of their decisions and actions. Preferences can have many roots, ranging from culturally transmitted tastes for food or other items to personal habits and commitments. Beliefs refer to perceived cause-and-effect relations, including the perceived likelihood of an individual's actions resulting in different possible outcomes. Constraints define the limits to all feasible actions. The concept of rational choice is a cornerstone of so-called neoclassical economics.

The term 'neoclassical economics' was coined in 1900. The neoclassical approach is the most widely taught theory of economics but has its critics. Neoclassical economists believe that a consumer's primary concern is to maximize personal satisfaction. Therefore, they make purchasing decisions based on their evaluations of the utility of a product or service. This theory coincides with rational behavior theory, which states that people act rationally when making economic decisions.

Furthermore, neoclassical economics stipulates that a product or service often has value beyond its production costs. While classical economic theory assumes that a product's value derives from the cost of materials plus the cost of labor, neoclassical economists say that consumer perceptions of the value of a product affect its price and demand.

Finally, this economic theory states that competition leads to an efficient allocation of resources within an economy. The forces of supply and demand create a market equilibrium. Key ideas of the neoclassical approach can be traced back to the writings of moral philosophers such as Adam Smith. There are three key assumptions in this approach:

- individuals have selfish preferences,
- they maximize their own utility, and
- they act independently based on full information.

This oversimplified and highly stylized conceptualization is represented by "Homo economicus" as a rational decision-maker. These assumptions have also met increasing criticism from within the discipline of economics, resulting in adjustments and the birth of "behavioral economics".

Rationality itself can be conceptualized in different ways. Some versions of rational choice theory assume so-called "full rationality":

- individual decision-makers are fully informed about all their decision alternatives,
- the probabilities of their outcomes,
- their consequences, and
- there are no cognitive limitations to the perception of the processing of this information.

Individuals base their decisions on cost-benefit calculations and choose the alternative that generates the highest expected utility. But rational choice theory cannot explain the existence of certain social phenomena such as altruism, reciprocity, and trust, and why individuals voluntarily join associations and groups where collective rather than individual benefits are pursued.

Bounded rationality

In 1957, Nobel price winner Herbert Simon proposed the concept of bounded rationality with relaxed assumptions about the level of rationality on the part of the decision-maker. Rationality is bounded because there are limits to our cognitive capacity, available information, and time. Selective attention limits the amount and kind of information processed, and limited information processing capabilities lead to satisfaction rather than maximization. In other words, individuals tend to accept solutions that are "good enough". In addition, the available information regarding possible alternatives and their consequences is limited and often unreliable. Hindrances to perfectly rational decision-making include:

- Complexity: The problems that need solving are often exceedingly complex, beyond understanding
- Time and money constraints: There is not enough time and money to gather all relevant information
- Differences in cognitive capacity, values, skills, habits, and unconscious reflexes: Not all managers are the same, of course, and all have personal limitations and biases that affect their judgment
- Imperfect information: Managers have imperfect, fragmented information about the alternatives and their consequences
- Information overload: There is too much information for one person to process.
- Different priorities: Some data are considered more important, so certain facts are ignored.
- Conflicting goals: Other managers, including colleagues, have conflicting goals.

Bounded rationality explains that cognitive blinders prevent people from seeing, seeking, using, or sharing relevant, accessible, and perceivable information during decision-making. The bounded rationality phenomenon challenges traditional rationalist perspectives, and suggests that the rationality of human and company behavior is always partial, or 'bounded' by human limitations. This concept recognizes that decision-making takes place within an environment of incomplete information and uncertainty. Herbert Simon pointed out that most people are only partly rational, and are in fact emotional and irrational in the remaining part of their actions. They experience limits in defining and solving complex problems, and in processing (receiving, storing, retrieving, transmitting) information.

Decision-making styles

Decision-making styles reflect how a manager perceives and responds to information. Value-oriented decision-making styles focus on the task or the people who are effected by a decision. Managers should have a certain tolerance for ambiguity. This is the extent to which a manager needs structure or control in their life.

- A directive decision-making style means that people are efficient, logical, practical, and systematic in their approach to such problems.
- An analytical decision-making style means that the decision-maker considers different kinds of information and alternatives.
- A conceptional decision-making style means that the decision-maker takes a broad approach to problem solving and likes to consider many options and future possibilities.
- A behavioral decision-making style means that the decision-maker is supportive, receptive to suggestions, shows warmth, and prefers verbal to written information.

Behavioral economics and behavioral decision-making

Nobel prize winners George Akerlof and Joseph Stiglitz focused on decision-makers who may not have complete information. Different decision-makers may have different amounts of information, which is called information asymmetry. However, decision-makers are still assumed to make the 'best' choice given the information they have. The work of Stiglitz and Akerlof extended the realism of conventional neoclassical theory and has been widely absorbed into mainstream economics. This stream of research is called "information economics".

In 2002, Daniel Kahneman and Amos Tversky published their seminal and groundbreaking work on decision-making. Essentially based on a series of experiments, in which there is a 'rational' answer, but people frequently fail to choose it, they drew the conclusion that decision-makers reason poorly and act intuitively. They observed systematic deviations from rationality, and even that rational firms take commercial advantage of consumers acting irrationally. This field of economics is called behavioral economics. It is the study of psychology as related to economic decision-making processes of individuals and institutions. The key questions in this field are whether economists' assumptions of utility and profit

maximization are good approximations of real people's behavior and whether or not individuals maximize the subjectively expected utility.

Behavioral economics draws on psychology and economics to explore why people sometimes make irrational decisions, and why and how their behavior does not follow the predictions of economic models. Decisions such as how much to pay for a cup of coffee, whether to go to graduate school, whether to pursue a healthy lifestyle, how much to contribute towards retirement, etc. are the sorts of decisions that most people make at some point in their lives. Behavioral economics seeks to explain why an individual decided to opt for option A instead of option B.

Because humans are emotional and easily distracted beings, they make decisions that are not in their self-interest. For example, according to rational choice theory, if Charles wants to lose weight and is equipped with information about the calorie count of each food product, he will only opt for the products with the lowest number of calories. Behavioral economics states that even if Charles wants to lose weight and sets his mind on eating healthy food going forward, his eventual behavior will be subject to cognitive bias, emotions, and social influences. If a commercial on TV advertises a brand of ice cream at an attractive price and quotes that all human beings need 2,000 calories a day to function effectively, the mouth-watering ice cream image, price, and seemingly valid statistics may lead Charles to fall for the sweet temptation and fall off the weight loss bandwagon, thus demonstrating a lack of self-control.

Behavioral economics explains that human beings are far less rational computing machines than anxious, moralizing, herd-like, reciprocating, image-conscious, story-telling game theorists.

Although many consumers are concerned about the environment, for instance, only a small proportion of consumers put their concern into purchasing practice in the marketplace. In other words, even when consumers have a positive attitude towards environmental issues, they tend to be rather passive in their purchase decisions. In the literature, this is called the "attitude-behavior gap" or "value-action gap", which is the recognition of a disparity between stated attitudes and actual behaviors. It is thus claimed that attitudes alone do not influence consumers' decision-making enough to turn into sustainable purchase behavior.

In addition, there has been a long-standing debate in the literature about the commonly cited "energy-efficiency gap", describing the absence of energy-efficient investments that appear to be cost-effective when looking at the estimated life-cycle cost. Lack of information, imperfect markets, organizational barriers, or limited access to capital are possible explanations why consumers underinvest in energy efficiency. Several of these market and non-market failures are directly linked to individual decision-making, including the existence of relatively high "implicit discount rates" of consumers, for instance, who have to decide between appliances with different costs and energy efficiencies. Implicit discount rates ranging from 25 to over 100 percent have been discussed in the literature.

Influencing effects on decisions: the power of framing and time inconsistency

The way different elements of a decision, which means alternatives, attributes, outcomes, and probabilities are presented might lead to different decision outcomes. Rational choice, however, would assume that preferences between the different options should stay the same. Framing effects are thus often taken as an explanation for irrational management decisions.

- Loss aversion:
  If a decision is framed as a choice between losses and gains, individual preferences are not fixed, although the expected value would be identical in both choice contexts described by prospect theory.
- Defaults:
  One other framing effect, also showing that indivdual preferences are not fixed or invariant, is that managers do not usually look for and process all relevant information. This is why preferences can be biased towards the initial anchor point, or the status quo or default option. The power of defaults is well-known from different fields, and is described as being the option that managers adopt if they do not explicitly ask for another option.
- Decoy effect:
  A decoy is an alternative that is added to a consideration set so that the relative attractiveness of other alternatives changes. As managers rarely make decisions in absolute terms, but have an "internal value meter that tells them how much things are worth", they much rather concentrate on the relative advantage of one alternative over another.
- Choice overload:
  In contrast to popular belief, behavioral economists show that more choice options are not necessarly "better". The choice overload hypothesis suggests that too many choice options can lead to information overload and ultimately prove to be demotivating. This can lead to managers getting overwhelmed by all the different choice options and be even more likely to adopt the default solution.
- Time inconsistency:
  One explanation of behavioral economics as to why managers do not consistently make rational choices is time inconsistency. In contrast to time consistency, where present consumption is traded off for future consumption at a constant discount rate, there is a body of empirical and experimental evidence showing that managers often do not make decisions based on a constant discount rate, and that hyperbolic or proportional discount functions represent managers' value costs and benefits over time more accurately. Hyperbolic discounting describes that managers are impatient and strive for immediate gratification. This effect mainly occurs when decisions are characterized by immediate costs but with delayed benefits. Time inconsistency

implies that managers heavily discount future savings, which has a significant impact on the way in which managers attach value to the efficiency or lifetime operating costs of investments.

Chapter 5 | Economic relevance of IP assets

Introduction to decision analysis

Decision analysis can generically be defined as follows: "Decision analysis is an analytic and systematic approach to studying decision making". A good decision is one that is based on logic, considers all available data and possible alternatives, and applies the qualitative and quantitative approaches to solve them. Decision analysis is a method by which non-transparent situations can be made transparent so that every one knows what to do relative to their objectives. In fact, if situations were transparent enough, people probably would not make bad decisions.

Decision analysis provides structure and guidance for thinking systematically about difficult and important decisions. It allows decision-makers to take action with confidence, based on a clear understanding of the problem. Along with a conceptual framework for thinking about difficult problems, decision analysis provides analytical tools that can make the required thinking easier.

The purpose of studying decision analysis is to help decision-makers think systematically about complex and important decisions and thus improve the quality of the resulting decisions. It is important to distinguish between a good decision and a lucky outcome. A good decision is one that is made on the basis of a thorough and complete understanding of the problem, and which is carefully thought through when it comes to important issues. A good decision does not depend on the outcome: the quality of the decision depends on the knowledge it is based upon and on the logic applied when making such a decision.

This understanding of quality is also very important when it comes to valuation. As valuation is merely a simplification of decision analysis which focuses on the monetary outcome of a certain option, the reasoning regarding quality is identical. Quality in valuation is not achieved by making lucky forecasts of future economic outcomes of business, trade, or negotiations. Quality in valuation comes for procedural quality of the valuation process, a profound understanding of the valuation scenario, and the application of an appropriate valuation model for modelling the real decision and determining a decision value.

Outcomes, on the other hand, may be lucky or unlucky regardless of the quality of a decision. In the long run, managers will be more likely to achieve their goals (min. cost, max. profit, etc.) if they follow high-quality decision making processes. In the short run, however, they may not get the best answer regarding future developments which were not forseeable at the time the decision was made.

Decision-making is used to identify decisions within three environments or cases:

- Decision-making under certainty
- Decision-making under uncertainty

- Decision-making under risk

When it comes to decision-making under certainty, the decision-maker tends to maximize returns or minimize costs by choosing the decision that satisfies those problem criteria where the outcome can be anticipated with certainty.

With decision-making under uncertainty, the decision-maker cannot estimate or anticipate the probability of occurance of the events and the respective outcomes of each decision alternative. Three decision-making types are available in these cases:

- Optimistic (Maximax)
- Conservative (pessimistic, Maximin), and
- Minimum regret method (Minimax)

As far as decision-making under risk is concerned, the decision problem is probabilistic, i.e. the decision-maker can estimate or anticipate the probability of occurrence of events and the respective uncontrollable outcomes associated with each decision alternative (also known as 'state of nature'). In this case, the decision-maker tends to maximize their expected return or minimize the expected loss, using the corresponding criteria.

Example: investment in an innovation

The decision to be made in this example is whether or not to invest in the patent protection of an invention. The available alternatives are:

- File one patent related to the invention
- Opt for a full portfolio covering the business model of the innovation
- Do nothing

The possible outcomes are:

Depending on the potential market success of the invention (high, moderate, or low), IP managers can develop a decision matrix containing all available information, including the so-called payoffs (see Table 3):

	Outcomes (Demand)		
Alternatives	High success	Moderate success	Low success
Full portfolio	200	100	-120
One patent	90	50	-20
Do nothing	0	0	0

Table 3: Elementary Decision Matrix

Once a payoff table has been created, a decision modeling method has to be applied: decision-making under certainty, uncertainty, or risk.

Decision-making under certainty means that all consequences of every alternative are known by the decision-maker and there is usually only one outcome for each alternative. In reality, this kind of decision occurs very rarely. Decision-making under uncertainty especially means that the probabilities of the possible outcomes are not known and the decision-maker has to use decision-making methods:

- Maximax criterion
  This is the optimistic approach which assumes that the best payoff will occur for each alternative.

	Outcomes (Demand)		
Alternatives	High success	Moderate success	Low success
Full portfolio	200	100	-120
One patent	90	50	-20
Do nothing	0	0	0
Choose the full portfolio (best payoff)			

Table 4: Decision Matrix for the Maximax criterion

- Maximin criterion
  This is the pessimistic approach which assumes that the worst payoff will occur for each alternative.

	Outcomes (Demand)		
Alternatives	High success	Moderate success	Low success
Full portfolio	200	100	-120
One patent	90	50	-20
Do nothing	0	0	0
Do nothing (best payoff)			

Table 5: Decision Matrix for the Maximin criterion

- Realism criterion
  This approach uses the coefficient of realism (α) to estimate the decision-maker's optimism. For α, a value between 0 and 1 is used: $0 \leq \alpha \leq 1$

$$\begin{aligned} &\alpha \times (\text{max payoff for alternative}) \\ &+ (1-\alpha) \times (\text{min payoff for alternative}) \\ &= \text{Realism payoff for alternative} \end{aligned}$$

Equation 1: Equation fort he realism criterion with a coefficient of realism (α)

For example: α = 0.45

Alternatives	Realism Payoff
Full portfolio	24
One patent	29.5
Do nothing	0
Choose one patent	

Table 6: Matrix for the realism criterion

- Equally likely criterion
  This approach assumes that all outcomes are equally likely and uses the average payoff.

Alternatives	Average Payoff
Full portfolio	60
One patent	40
Do nothing	0
Choose the full portfolio	

Table 7: Matrix for the equally likely criterion

- Minimax regret criterion
  This approach measures the regret or opportunity loss occurred when decision-makers take one decision over another. Regret = (best payoff) – (actual payoff)

Alternatives	Outcomes (Demand)		
	High success	Moderate success	Low success
Full portfolio	200	100	-120
One patent	90	50	-20
Do nothing	0	0	0
The best payoff for each outcome is highlighted			

Table 8: Matrix for the Minmax regret criterion

These figures allow us to determine the regret values:

Alternatives	Outcomes (Demand)			Max regret
	High success	Moderate success	Low success	
Full portfolio	0	0	120	120
One patent	110	50	20	110
Do nothing	200	100	0	200

Table 9: Matrix for the Minmax regret criterion with regret values

When regret minimization is to be achieved, protection of the invention should be opted for.

When decision-making takes place under risk, the possible outcomes are associated with certain probabilities. This means that there is a probabilistic stable situation.

General definitions of probability

At the most general and abstract level, there are two definitions of probability economists as social scientists could adopt. On the one hand, they could choose to define probability as a measure of an objective, real, physical property of the world. According to this definition of objectives, probability could be conceived as something "out there" in the world that can be measured, recorded, and analyzed in a similar way as the hardness of different metals, for instance. Just as aluminum and cobalt have different physical properties that we can observe and measure, so too do actions and events.

On the other hand, we could choose to define probability not as an objective physical property, but rather as a measure of our subjective beliefs about what is going to happen in the world. According to this subjective definition, there is no such thing as physical probabilities "out there" in the world, because events and actions in the world are all governed by the principle of "causality", meaning that nothing in the world is random or accidental.

In the natural world, events occur as a result of a certain force or forces. Leaves do not simply fall from trees for no reason, nor does any other event in the world occur for no reason. Similarly, in the realm of human action, an action occurs because the actor perceives greater value in acting than in not acting. There is no such thing as an action that occurs for no reason whatsoever. In other words, there is a causal explanation for everything that occurs in the world, and probability is a way to measure and try to overcome human ignorance with respect to those causal explanations.

Economists as social scientists must decide which of these two general definitions of probability to adopt. If they genuinely seek to understand the world they live in, they must adopt the definition of probability that most accurately describes to the phenomena they

are seeking to define and study. Therefore, IP managers should choose the physical definition of probability based on relative frequencies. The relative frequency theory of probabilities holds that, if an experiment is repeated an extremely large number of times and a particular outcome occurs with a certain frequency, then the corresponding percentage value of the occurrence of that outcome is close to the probability of that outcome. In other words, a probabilistic stable situation is necessary for all of these observations of outcomes. In a valuation scenario, this can be conceptualized by drawing from a comparable situation.

Decision-making under risk

This approach can be used when probabilities of outcomes are available and therefore observable under probabilistic stable circumstances.

- Expected monetary uses
  This approach uses the determination of probabilistic expected monetary values (EMV) for calculating the average payoff for each alternative:

  EMV (for alternative i) = ∑ (probability of outcome) x (payoff of outcome)

Alternatives	Outcomes (Demand)			EMV
	High success	Moderate success	Low success	
Full portfolio	200	100	-120	86
One patent	90	50	-20	48
Do nothing	0	0	0	0
Probability of outcome	0.3	0.5	0.2	
Choose the full portfolio				

Table 10: Matrix for the expected monetary value

- Expected opportunity loss (EOL)
  This approach determines how much regret (opportunity loss) the decision-maker expects based on the given probabilities?

  EOL (for alternative i)= ∑ (probability of outcome) x (regret of outcome)

Alternatives	Outcomes (Demand)			EOL
	High success	Moderate success	Low success	
Full portfolio	0	0	120	24
One patent	110	50	20	62
Do nothing	200	100	0	110
Probability of outcome	0.3	0.5	0.2	
Choose the full portfolio				

Table 11: Matrix for the expected opportunity loss

The decision analysis process

Decision analysis is performed using the process shown in figure 3. It starts with a real decision problem a decision-maker is facing, which must be opaque if the analysis is to produce truly useful results. The intention is to apply a sequence of transparent steps to provide such clarity of insight into the problem that the decision-maker will undertake the recommended action. The first step of the decision analysis process follows a formal model to describe the decision-maker's opaque real situation, also known as formal representation of the problem or "decision basis". The decision basis must be evaluated by a primarily computational process to produce the alternative that is logically consistent with the basis and therefore recommended. Then an appraisal of the analysis is performed to gain insights into why the recommended alternative is not only logically correct, but so clearly persuasive that the decision-maker will act accordingly. The appraisal may well reveal some shortcomings of the analysis, requiring a refinement of the formulation to assure that it is truly appropriate to the problem. At some point, the appraisal step will show that the recommended alternative is so right for the decision-maker that there is no point in continuing the analysis any further.

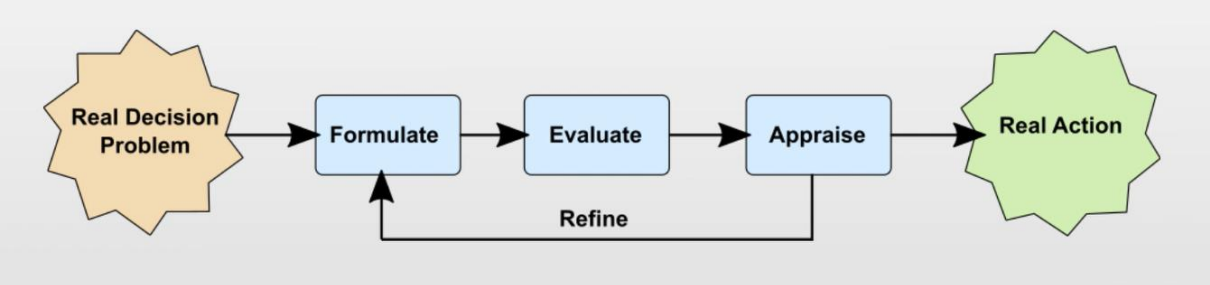

Figure 3: Decision analysis process with the sequence of steps from formulation to appraisal.

The core of this process is the elicitation of synthesis for the decision basis. Figure 4 shows the role of the basis in more detail. The basis consists of three parts: the choices or alternatives the decision-maker faces, the relevant information, and the decision-maker's preferences.

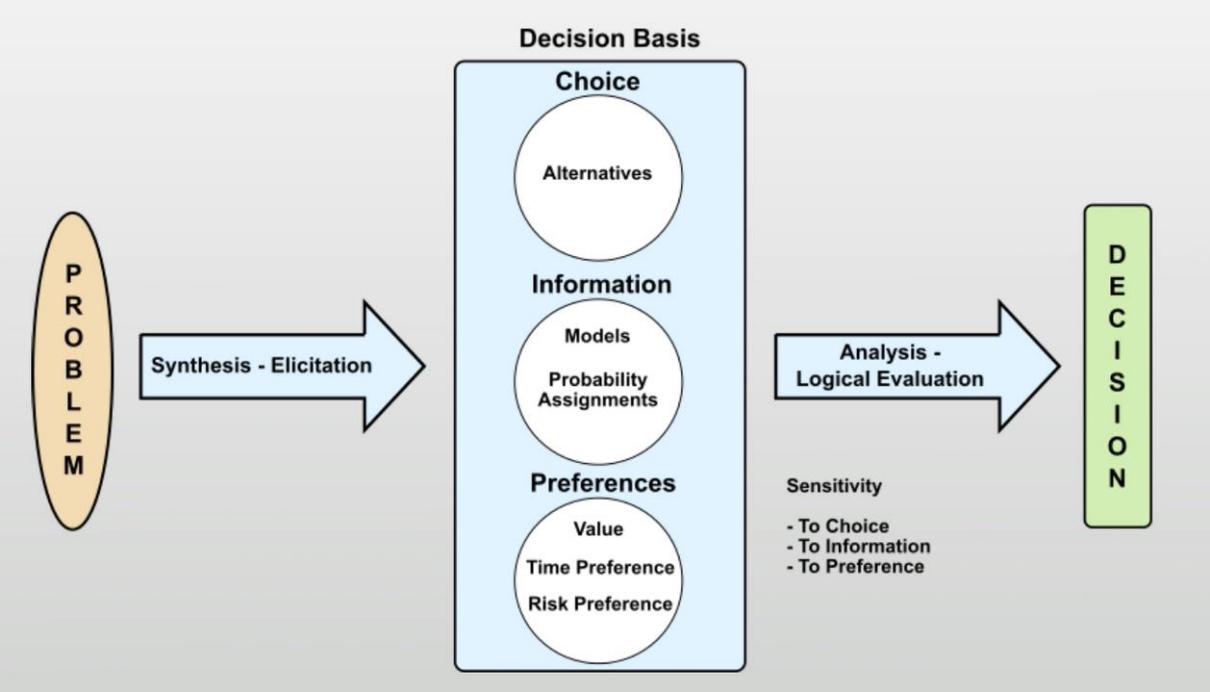

Figure 4: Detailed description of the decision basis. Parts of the decision basis are the choice, information and preferences.

The alternatives may be readily available or it may require significant effort to generate them. Information refers to any models, relationships, or probability assignments that may be important in characterizing the connection between decisions and outcomes. The models can be complex and dynamic, or, in some cases, very simple. The remaining uncertainty could be characterized by probability assignments. The preferences of the decision-maker can be represented in at least three dimensions. The decision-maker must choose one outcome over another, and take into account time preference considerations relating to achieving outcomes now versus achieving outcomes later. Finally, the decision-maker will have a risk preference relating to outcomes with different degrees of certainty. With this decision basis in place, the decision-maker can proceed with their evaluation. Logical operations are applied in order to select the best decision alternative. The appraisal takes into account sensitivities related to choice, information, and preferences.

Chapter 6 | Economic relevance of IP assets

Types of decisions in management

For practical application, it is helpful to distinguish between different types of decisions such as management decisions. It is important to understand the different qualities of decisions in order to use the right decision-making process. Relatively minor decisions are taken almost subconsciously, following rules and patterns of behavior established over many previous encounters with the problem. All major decisions, however, are taken very carefully and consciously. Such decisions usually involve the application of considerable human judgement and experience before a solution is obtained. Here are some types of managerial decisions, which can be conceptualized as dichotomies:

- Organizational vs. personal decisions
  Organizational decisions are made to advance the interests of the organization. When an executive acts formally in their expected role within an organization, they make organizational decisions. Making official decisions also means delegating power to others and calls for supporting decisions at subordinate levels.

  They are thus thought of as a chain of behavior spanning the entire organization. Personal decisions are made by an executive as an individual and not as part of an organization. An executive who changes job or organization is making a personal decision. Buying a house or purchasing a car are further examples of personal decisions. Such decisions made by an executive may affect that executive's personal life, but it may sometimes also affect the organization, either directly or indirectly.

- Individual vs. group decisions:
  When a decision is made by an individual in the organization, it is called an individual decision. Such decisions are mainly concerned with routine problems for which broad policies are available. They are generally taken in small organizations and in organizations with an autocratic management style. Group decisions are taken by a group of persons constituted for that purpose. Decisions made by the board of directors or a committee are examples of group decisions. Group decision-making generally results in more realistic and well-balanced decisions and encourages participative decision-making.

- Routine vs. strategic decisions:
  Routine decisions are made repetitively following certain established rules, procedures, and policies. They do not require the collection of new data and can be taken without much deliberation. Such decisions are generally taken by the executives at mid and lower management levels.

Strategic or basic decisions, on the other hand, are more important and are generally taken by the top management of organizations. They relate to policy matters and therefore require thorough fact finding and analysis of the available alternatives. Launching a new program, choosing the location of a new plant, and installing a computer system are examples of strategic decisions.

- Programmed vs. non-programmed decisions:
  Programmed decisions are concerned with relatively routine and repetitive problems. Information on these problems is already available and can be processed in a pre-planned manner. Such decisions have a short-term impact and are relatively simple. They are made at lower levels of management. These decisions require little thought and judgement. The decision-maker identifies the problem and applies the predetermined solution. For example, if an employee is habitually late, they can easily be dealt with under an established procedure. Non-programmed decisions deal with unique or unusual problems. Such novel or non-repetitive problems cannot be dealt with in a predetermined manner. Executive judgment and deliberation are required to solve them. Examples of such decisions include firing a rioting mob, imposing a curfew in the city, and the opening of a new branch. The ability to make good non-programmed decisions helps to distinguish effective executives from non-effective executives.

- Policy vs. creative decisions:
  Policy decisions are of vital importance and are taken by top management. They affect the entire organization. Operating decisions in order to put policy decisions into action, however, are taken by lower management. Whether employees receive a bonus is a policy matter, for instance, which is to be decided by top management. Determining the bonus amount, however, is an operating decision, which is taken at lower levels.

Types of decision making

In analogy to these decision-making types, there are also classifications for the ways in which decisions are made in management:

- Irreversible:
  These are the kinds of decisions that, once made, cannot be canceled. It is key to bear in mind the long-term impact of such decisions. A manager should never use it as an escape from his own indecision.

- Reversible:
  These are decisions that can be changed at any time, either before, during, or after the implementation of the agreed measures. These types of decisions can recognize

an error early in the process rather than perpetuating it. They can be effective in various scenarios in which inversion is necessary.

- Experimental:
  These types of decisions are not final until the first results are in and are deemed satisfactory. Positive feedback is required before we decide on a course of action. Experimental decisions are useful and effective if a proper process is not clear but there is a general clarity on the purpose of the action.

- Trial and error:
  In this type of decision-making, knowledge of past mistakes is operationalised. Some action is taken and tested. If the results are positive, the action continues. If the results are negative, another course is adopted. This process continues until the right combination of actions has been found. This decision-making type is useful for supporting the manager and adjusting plans continuously before making a full and final commitment. It uses both positive and negative feedback to come up with an action plan.

- Made by steps:
  Here, decisions are made in stages until the entire process is complete. It permits close monitoring of risks and collecting evidence for external obstacles at every step, as well as feedback and discussion before the next decision-making step.

- Cautious:
  It allows time for unforeseen problems that can arise later in the implementation. Decision makers save their best efforts to adopt the right path. It helps to reduce the risk decision. While this may also limit the final earnings, it reduces some projects that seem too risky at first.

- Conditional:
  These types of decisions can be changed only if certain conditions are met. Their "either/or" nature keeps all options open. They help to provide clarity on whether the competition changing direction, or whether drastical changes to one's own game plan are required. They enable a rapid response to the changing realities of competitive markets.

- Delayed:
  These decisions will be queued until policymakers believe that their time has come. The green light will only be given if the required elements are present. This prevents us from making a decision at the wrong time or before all the facts are known. It can sometimes lead to the loss of opportunities in a market demanding rapid action.

- Authoritative:
  In the authoritative style of decision-making, the decision comes from the top and is binding. When the CEO, president, or other leader has all the facts and is the undisputed expert on the topic or situation, they can make effective decisions. If there is untapped expertise or additional information available elsewhere, this kind of decision-making process may not provide the best results.

Static and dynamic decision situations

Compared to static tasks, the major characteristic of a dynamic situation is that it changes over time, which occurs both autonomously and as a result of actions taken by a decision-maker (see Table 12). What is of importance to dynamic decision-making is therefore the possibility to affect the development of the system over time. In contrast to static decision-making, where only one decision needs to be made based on the available information, dynamic environments offer the possibility to adjust incorrect decisions through continuous feedback on the overall system state. It is therefore to be expected that the outcome will be better in a dynamic decision-making scenario than in a static task environment.

Temporal Interdependencies	Static	Dynamic
	Decisions are independent from later decisions and the timeline of outcomes > **single-stage decisions**	Decisions are **inter**dependent and logically connected with later decisions (decision sequence) > **multi-stage decisions**

Table 12: Comparison of static and dynamic decision situations

Research shows, however, that making decisions on complex tasks is very challenging for humans. People do not always make better decisions when they have experience in a task, and their performance may even remain suboptimal when they are given full and immediate feedback, unlimited time, and high-performance incentives. People are generally poor at handling systems with long feedback delays as is typical for IP scenarios. Unfortunately, highlighting suboptimal performance and the poor strategies people use in handling these tasks does not provide insights into how people actually make decisions, and in the basic processes required in order to improve decision-making.

Even tasks which may seem simple on the surface can have a dynamic complexity which emerges from the relationship between choices and their effects over time, from the sequential nature of these interdependencies, and from the various lags between actions and their effect on the environment. Furthermore, dynamically complex tasks that are structurally simple are very common in management situations – for instance, the question of whether or not a cooperation partner on a specific development project should be sued

for infringement. There is a timeline or response to enforcement. In addition, it is the question how the development project will perform and there are other partners who could react to this action.

Decisions involving multiple objectives

The traditional paradigm for analyzing decision-making is based on three key elements:

- A decision-maker
- An array of feasible choices
- A well-defined criterion (for example utility of profit)

The criterion assigns a number to each alternative. Alternatives are ranked to find the optimal value for the chosen criterion. The best option, which could mean highest or lowest value, is subsequently selected. In reality, however, decision-makers appear to pursue several objectives, meaning that the traditional paradigm of choice involving a single criterion might be inadequate for dealing with such situations or decision environments. In fact, multiple objectives tend to be the rule rather than exception in many real-life management decision-making scenarios. In IP management, for example, portfolio maintenance should lead to lowest possible costs, offer many future development and business opportunities, disclose no information to third parties, effectively block new entries, and be a source of licensing income. What is more, most decisions might not only involve multiple objectives (goals), but also a hierarchy of objectives which might be potentially conflicting with each other and require reconciliation.

The traditional paradigm assumes that constraints are rigid and cannot be violated under any circumstances (see Figure 5). In many situations it is possible to accept a certain amount of violation, at least of some of the constraints, when the technical knowledge is not precise enough. Working with key performance indicators, leads to a valuation with qualitative characteristics.

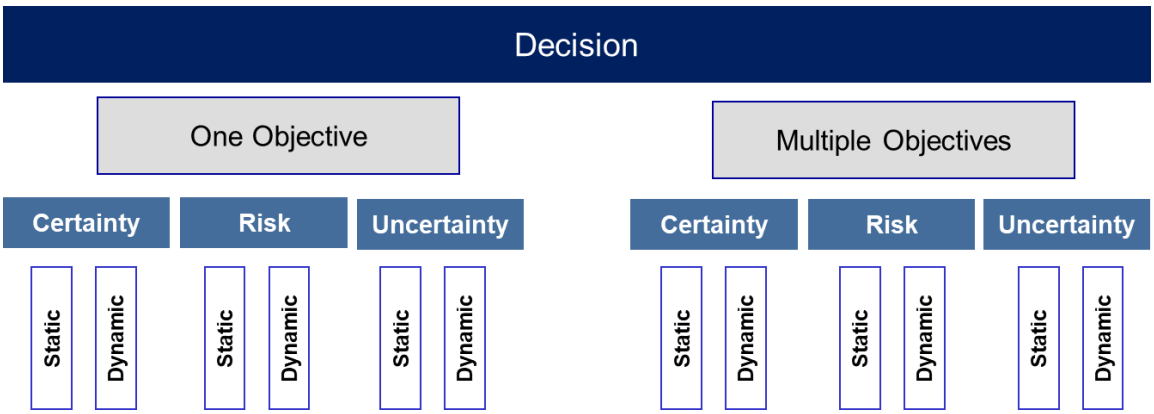

Figure 5: Classification of decisions as: One vs. multiple objectives, under certainty, risk or uncertainty and static vs. dynamic.

The limitations of the human mind mean that people use 'approximate methods' to deal with most decision-making problems. This phenomenon is also called bounded rationality (see "Descriptive decision theory – Decision-Making"-> IP-Valuation (I): Part 1 Chapter 4). As a result, decision-makers seek to identify satisfactory rather than optimal courses of action. These approximate methods, or rules of thumb, are often referred to as 'heuristics' (see "Decision theory and cognitive biases"-> IP-Valuation (I): Part 1 Chapter 2).

Compensatory vs. non-compensatory strategies

Compensatory strategies are characterized by poor performance on some attributes which is compensated by good performance on others; this is not the case in a non-compensatory strategy. Compensatory decision-making strategies are rational decision choices for multi-attribute utility models. Compensatory decision-making involves identifying a set of attributes applicable to the decision, assigning a relative importance or weight to each attribute, computing an overall score for each option based on the attribute weight, and selecting the option with the best score. Compensatory decision-making is based on utility maximization, since the option(s) with the highest sum of weighted utilities are selected. In compensatory decisions, a negative value on one attribute can be compensated by an equal or higher value on another attribute. Compensatory strategies are characterized by poor performance on some attributes which is compensated by good performance on others.

By contrast, non-compensatory decision rules are those that shortcut or simplify the compensatory process by applying heuristics in order to quickly evaluate the alternatives with minimal effort. This could mean that, even when additional information is available, the decision will be based on only a small part of the available data.

Decision trees, expected monetary value, and risk management

Business, project, and IP management decisions vary by situations, which in-turn are fraught with threats and opportunities. Calculating the expected monetary value of each possible decision path is a way to quantify each decision in monetary terms. Calculating expected monetary value by using decision trees is a recommended tool and technique for quantitative risk analysis, which can show how decision analysis and valuation are correlated.

Suppose an organization is using an IP administration software. Some influential stakeholders believe that, by upgrading this software, your organization can save millions, while others feel that staying with the current software is the safest option, even though it does not meet the company's current needs. The stakeholders supporting the upgrade of the software are further split into two factions: those that support buying the new software and those that support building the new software in-house. Confusion reigns in the meeting room with stakeholders pointing out negative risks for each option.

By exploring all possibilities and consequences, managers can quantify the decisions and convince stakeholders. This is known as decision tree analysis. The following decision trees

example uses decision tree analysis to help make an informed project risk management decision. The computations involve calculating the expected monetary value.

In this scenario, the company can either:

Build the new software: The associated cost for building the new software is $500,000.

Buy the new software: The associated cost for buying the new software is $750,000.

Stay with the IP administration software: If the company decides to stay with the software, the associated cost is mainly related to maintenance and will amount to $100,000.

Looking at the options listed above, managers can start building the decision trees as shown in figure 6. By looking at this information, the lobby for staying with the current IP administration software would have the strongest case.

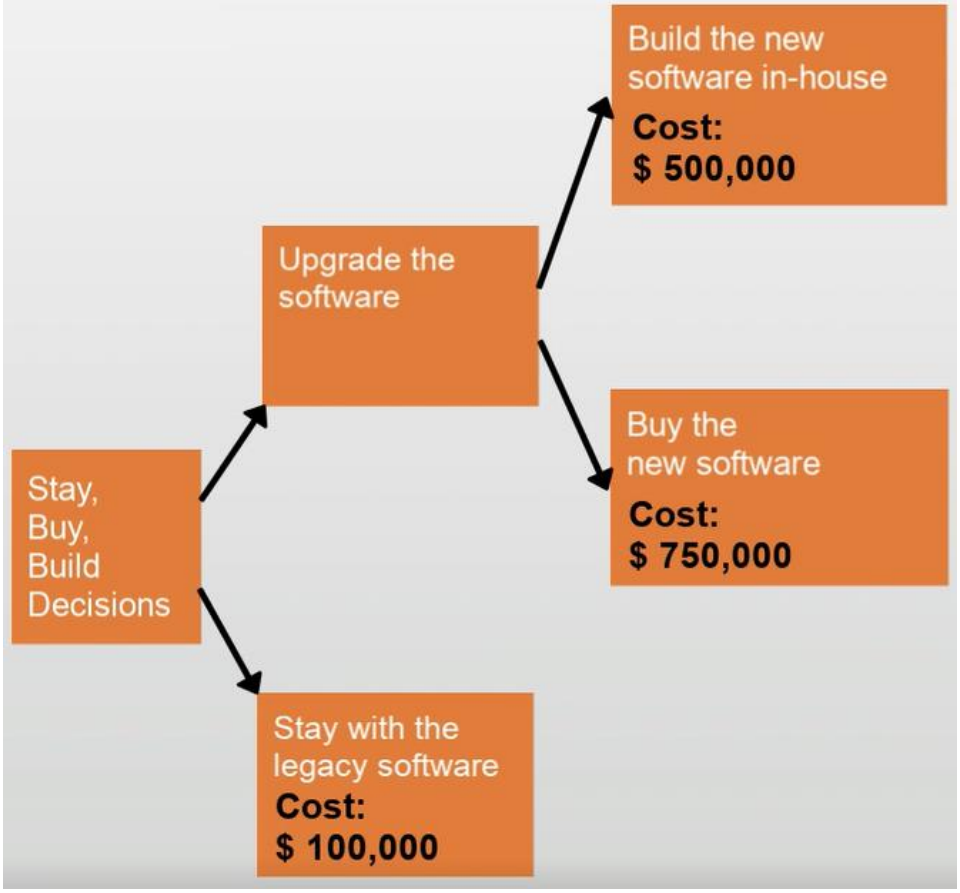

Figure 6: Decision tree for the scenario: Build the new software, buy the new software and stay with the old software

The "buy the new software" and "build the new software" options will either lead to a successful deployment or an unsuccessful one. If the deployment is successful, then the impact is zero, because the risk will not have materialized. However, if the deployment is

unsuccessful, then the risk will materialize, and the impact is $2 million. The "stay with the IP administration software" option will lead to only one impact, which is $2 million, because the legacy software is not currently meeting the company's needs, nor will it meet the needs should there be growth. In this example, it is assumed that the company will experience growth. In this example, decision trees analysis will be used to make the project risk management decision. The next step is to compute the expected monetary value for each path in the decision trees.

Figure 7 depicts the decision tree. Now, you can calculate the expected monetary value for each decision. The expected monetary value associated with each risk is calculated by multiplying the probability of the risk (see "IP as an investment object – security, uncertainty and risk"-> IP-Valuation (I): Part 3 Chapter 3) with the impact. In doing so, we obtain the following results:

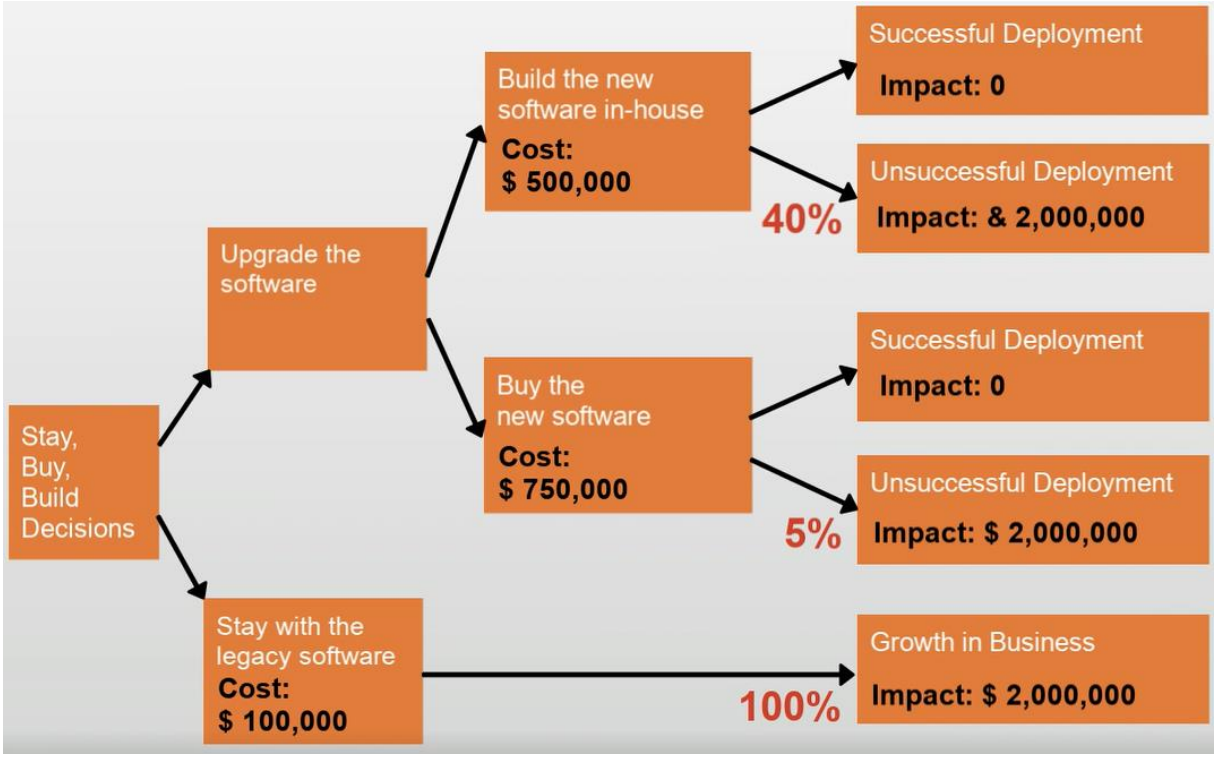

Figure 7: Decision tree for the scenario: Build the new software, buy the new software and stay with the old software with the impact in the cases of successful and unsuccessful deployment and growth in business.

Build the new software: $2,000,000 * 0.4 = $800,000

Buy the new software: $2,000,000 * 0.05 = $100,000

Stay with the legacy software: $2,000,000 * 1 = $2,000,000

Now, add the setup costs to each expected monetary value:

Build the new software: $500,000 + $800,000 = $1,300,000

Buy the new software: $750,000 + $100,000 = $850,000

Staying with the IP administration software: $100,000 + $2,000,000 = $2,100,000

The decision in this decision tree example can now be made. This illustrates the role of decision trees in project risk management and valuation.

Looking at the expected monetary values computed in this decision trees example, managers can see that buying the new software is actually the most cost-efficient option, even though its initial setup cost is the highest. Staying with the IP administration software is by far the most expensive option.

When managers conduct a SWOT analysis (see "SWOT analysis"-> IP Strategy Development: Part 7 Chapter 2) to determine whether a business idea is worth pursuing, there is no quantified data to support the decision. Decision trees and decision tree analysis help quantify the data, which can then be used to convince stakeholders (see figure 8). Decision analysis is a critical part of project risk management, and as this example demonstrates, decision analysis involves valuation in terms of determining expected values.

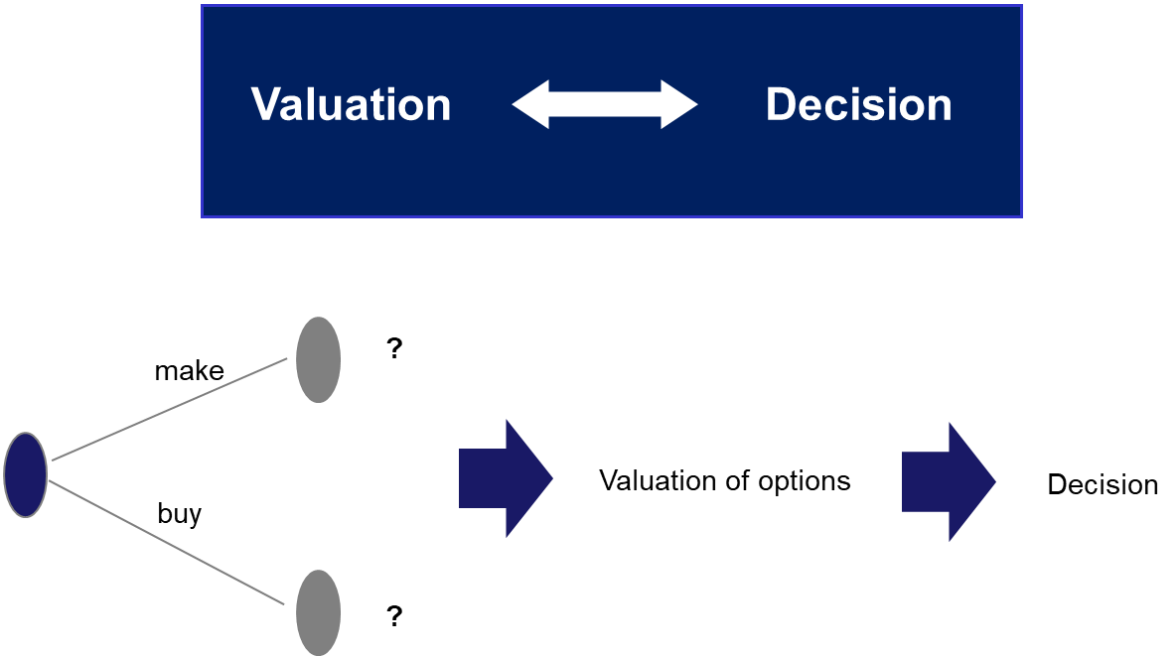

Figure 8: The use of decision trees helps to valuate the options and to make decisions. It provides the quantified data, that is needed to make meaningful decisions.