



Decision Making Environments

An Online Continuing Education Course for Engineers

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Decision Making Environments

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Introduction

The field of decision making is wide and vast. There are many different decision environments, availability of information, methods and tools, and opportunities to applied structured decision making to real-world applications. This course introduces decision analysis, various decision-making environments, and methods that can be used to evaluate decisions given the information available and level of certainty associated with this information. The course will focus on describing decision analysis, defining the decision evaluation matrix that can be used to assess alternative decisions, discuss the decision-making environment of certainty, risk and uncertainty and discuss some helpful hints in practical decision making. This course will address the following areas of decision making.

- Decision Analysis
- The Decision Evaluation Matrix
- Decisions under Certainty
- Decisions under Risk
- Decisions under Uncertainty
- Practical Decision Making

Students should complete the course with an understanding of these topics and how to apply the material with the examples given in the course.

Decision Analysis

Decision analysis is the systematic process and methodology of identifying, modeling, assessing, and determining an appropriate course of action for a given decision problem. This process often involves a wide array of tools, and the basic approach is generally to break the problem down into manageable and understandable parts that the decision-maker can comprehend and handle. When analyzing the decision-making process, the context or environment of the decision to be made allows for categorization of the decisions based on the nature of the problem or the nature of the data or both.

Decision analysis can be applied and used across all industry and government sectors and at every level of an organization. Decisions are made by individuals at every level of an organization on a daily basis. The array of methods and circumstances are vast. This course is intended to expose students to some primary environmental characteristics and methods that can

be used relatively simply in given circumstances. This course is just a beginning point in this field but does expose students to some primary areas and considerations in decision making. This course will focus on the general areas of decisions under certainty, decisions under risk, and decisions under uncertainty and provide some tools for students to use in each of these environments.

Decision making under certainty means that the data are known deterministically or at least at an estimated level, the decision-maker is comfortable with in terms of variation. In this circumstance, the decision characteristics, alternatives, bounds, and constraints can be well defined and relatively well modeled. Basically, under this condition, the decision-maker feels comfortable with the data that he or she has available and has the confidence that this information can be structured into an analytical model that can be used to solve the problem at hand. An example of this may be when a logistics firm models its delivery environment utilizing a route optimization computer package. There is a level of confidence based on past history and physical circumstances like road distances, etc. that the decision-maker can use analytical means to generate a decision as to how many trucks he or she needs to deliver the product to customers on a given day.

Decision making under risk means that there is uncertainty in the data, but this uncertainty can be modeled probabilistically. In this environment, the decision-maker has available to him or her fairly well-defined data, however, for those areas that uncertainty exists, the decision-maker is comfortable in assigning probabilities to represent the chance that various conditions occur. This is done relatively frequently when there is some base on institutional knowledge or expertise that lends itself to the assignment of these probabilities. A simple example of this may be seen with a weather forecaster. He or she will assign a probability that it will rain or be sunny on a daily basis. The decision-maker (weather person) has taken into account facts at hand, however, knows that these futures may or may not come to pass. It is an explicit statement of a probability of occurrence which is captured in the weather forecast.

It should be noted that there are some that do not use this designation since they believe all probability is subjective; hence all decisions not known with certainty are uncertain. However, this course will use the common convention of referring to probabilistic models as decision making under risk.

Decision making under uncertainty means the data cannot be modeled probabilistically and are imprecise or vague. In this circumstance, there is too little known about the future to provide robust information for decision making. This is a circumstance that no one would like to be true; however, in forward-looking decisions into the future and areas like new technology development, many aspects of the decision are vague. However, a decision must still be made and explicitly realizing that this data is not available can help to provide tools that can be used to provide general direction in the decisions being made.

These three environments represent reality in decision making. The goal of this course is to provide students with some tools that can be used to better make these decisions and solve these problems.

Terminology

As part of the process, some basic terminology should be introduced.

Decision Maker: The Decision Maker is the entity responsible for making the decision. This entity may be an individual, a committee, company, etc. The decision-maker can be at any level of the organization and be functioning in almost any capacity at their company. We must also include the personal decisions that are made, which might include buying a house, changing jobs, etc. Decision-making affects every area of our lives.

Alternatives: The Alternatives represent a finite number of possible decision alternatives or courses of action available to the decision-maker. The decision-maker generally has control over the specification and description of the alternatives. The alternatives are key to making good decisions. If all the alternatives presented to the decision-maker are poor, then the overall result of the decision will be poor. Constructing good alternatives is critical in the decision-making process.

States of Nature: States of Nature or Futures are the scenarios or states of the environment that may occur but are not under control of the decision-maker. As it is important to develop good alternatives, it is also very important to explore and define the possible states of nature associated with the decision. If, for example, certain possible occurrences and conditions are not identified and quantified, these futures could still occur and significantly affect the outcome of the decision. What is not known can significantly drive the results. Spending time exploring the states of nature or conditions around the decision is very important.

Outcomes: Outcomes are the measures of net benefit, or payoff, received by the decision-maker. This payoff is the result of the decision and the state of nature. The outcomes provide a measure of the desirability of the outcome of a decision. Typically, outcomes are measured in some type of benefit or payoff unit. However, they can also be represented from a negative sense in terms of loss. It is important also to develop good representative outcomes associated with each state of nature and alternative so that the differentiating factors associated with the decision are understood.

Probabilities: Probabilities are used in certain decision-making environments. When decisions are made with certainty, the probability associated with a state of nature is 100% or 1.0. When there are some other estimates of the chance of occurrence, those probabilities will fall somewhere between 0.0 and 1.0 for each of the states of nature. This means that the decision-maker is confident in estimating the chance that a certain state of nature will occur.

The Decision Evaluation Matrix

A decision can result in one of several outcomes based on future events. For example, a decision to go on a picnic can result in a high degree of satisfaction if the day turns out to be sunny. If it rains, the degree of satisfaction may be low. If the choice were to stay at home, the degree of satisfaction would be reversed where there is a high degree of satisfaction if it is rainy and a low degree of satisfaction if it is sunny. For these two different states of nature, rain, and sun, there are different payoffs depending on the alternative chosen. States of nature would represent a finite set of possible futures or outcomes. Speaking in terms of sales demand, you might have three different outcomes or payoffs if the demand is low, medium, or high.

The decision evaluation matrix is a formal way of exhibiting the interaction of a finite set of alternatives and a finite set of possible futures (states of nature). In this case, alternatives are a different course of action that a decision-maker can choose. In business, you may not be evaluating states of nature such as sun or rain. However, you may, for example, see low, medium or high product demand based on a given marketing campaign. The decision evaluation matrix can be applied to decision making under certainty, risk, and uncertainty, and there is an assumption that all of the alternatives presented in the decision evaluation matrix are feasible alternatives.

The general decision evaluation matrix is a model depicting the outcomes (better or worse) based on the occurrence of the identified states of nature for each of the alternatives identified in the model. This model assumes that the sphere of the decision environment has been captured such that all alternatives and potential states of nature have been identified. Alternatives not identified cannot be selected. States of nature not identified may significantly impact the range of outcomes in the decision problem.

A_i = alternative available for selection, where $i = 1, 2, \dots, m$

F_j = a future not under control of the decision maker, where $j = 1, 2, \dots, n$

P_j = Probability that the j th future will occur, where $j = 1, 2, \dots, n$

E_{ij} = evaluation measure (+/-) associated with the i th alternative and the j th future

	F_j				
A_i	F_1	F_2	...	...	F_n
P_j	P_1	P_2	...	...	P_n
A_1	E_{11}	E_{12}	...	...	E_{1n}
A_2	E_{21}	E_{22}	...	...	E_{2n}
...
...
A_m	E_{m1}	E_{m2}	...	...	E_{mn}

Evaluation in the matrix may be either subjective or objective data. If quantifiable payoffs such as profit are available, they can be represented as an outcome in the matrix. If subjective data is used, some type of scaling or ordinal ranking can be used to represent the outcomes. A few other assumptions in the use of this type of decision evaluation model are that the futures are mutually exclusive, where it can only, for example, be sunny or raining. Alternative selection does not drive the future, and the occurrence of a future is not known with certainty, even if we assume that it is.

Decisions Under Certainty

Decision making under certainty means that the data are known deterministically or at least at an estimated level, the decision-maker is comfortable with in terms of variation. The decision alternatives can be well defined and modeled. The techniques used for these problem types are many and include:

- Linear programming
- Nonlinear programming
- Integer programming
- Multi-objective optimization
- Goal programming
- Analytic hierarchy process
- And, many others

The evaluation matrix for decision making under assumed certainty is not a matrix at all. The evaluation matrix for decision making under certainty is a vector with single column outcomes representing alternatives. The single future is assumed to have a probability of

unity ($P = 1.0$) assuming all other futures having probabilities of zero ($P = 0.0$). Conceptual simplifications and models with assumptions are used to estimate a single known future.

When outcomes, E_i , are stated in monetary terms (cost or profit), the decision rule or choice is one that minimizes cost or maximizes profit

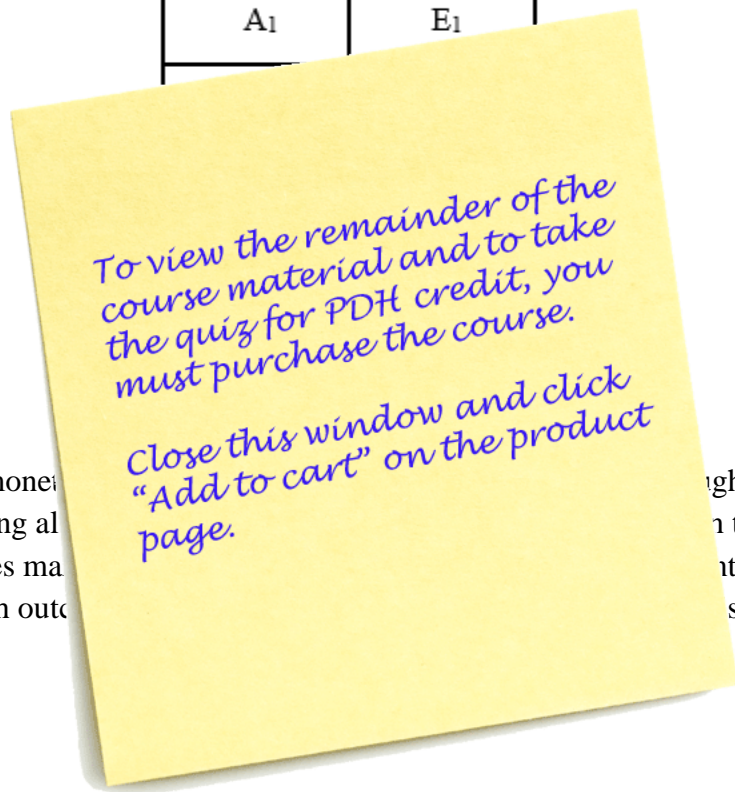
For cost

$$\text{Min}\{E_i\} \text{ for } i = 1, 2, \dots, m$$

For-profit

$$\text{Max}\{E_i\} \text{ for } i = 1, 2, \dots, m$$

	F_j
A_i	F_1
A_1	E_1



At times, other non-monetary costs and profits among all use of outcomes scales many alternatives, each with outcomes means can be used

ough to outweigh then be used. The most nonquantifiable story or other