



# Ranking Models for Decisions without Attribute Trade-offs

An Online Continuing Education Course for Engineers

**Course Number: P-2019**

**Credit: 2 Hours / 2 PDH / 2 CPD**

# Ranking Models for Decisions without Attribute Trade-offs

Deandra T. Cassone, PhD, PMP

## 1.0 Introduction

In corporate or government decision making, there typically are several attributes or characteristics associated with the alternatives that are presented for a decision. In many circumstances, these alternatives need to be screened or ranked. There are a number of different approaches and methods that can be used to capture the decision environment and provide structure to the decision-making process.

This course addresses decision making circumstances where the decision-maker is not permitted to make trade-offs between the attributes in the decision problem. An unfavorable value in one attribute cannot be offset by a favorable value in another attribute. Each attribute associated with an alternative must stand on its own. Comparisons between alternatives are made on an attribute-by-attribute basis.

There are a number of methods that fall into this category of decision models. Structuring the problem and key characteristics of the decision is important as is the selection of the approach to perform the ranking or screening. In investigating this field of study, one can see a large number of methods to choose from in this process. Researchers also develop new methods and extensions off of these methods. The methods discussed in this course are robust, “salt of the earth” types of methods that provide reliable and reasonable results. You may have used some of these methods or variations of them previously, however, not knowing the science behind the methods. In this course, a number of methods that do not allow for the compensation of attributes will be presented. These methods include the dominance method, maximin, maximax, conjunctive constraint method, disjunctive constraint method and the lexicographic method. These methods are relatively simple and easy to apply in real-world decision making.

The following are the topics covered in this course.

- Gaining an understanding of non-compensatory methods
- Understand the construction of the decision matrix
- The Dominance method
- The Maximin method
- The Maximax method
- The Conjunctive constraint method
- The Disjunctive constraint method
- The Lexicographic method
- The Lexicographic semi-order method

Initially, there will be a discussion of this general class of problems. These problems fall into a body of work called Multiple Attribute Decision Making (MADM) problems. The methods in this classification of problem fall into two major categories, those that allow for the compensation of attribute values (compensatory methods) and those that do not allow for the compensation of attribute values (noncompensatory methods), which will be discussed in this course. Additionally, we will discuss the basic structure used to evaluate these types of problems. This is called a decision matrix. The construction of the decision matrix will allow for the use of the various methods for evaluation. We will then discuss each of the methods listed above and provide an example of how each of the methods works.

## **2.0 Multiple Attribute Decision-Making Problems**

Decision-makers often deal with problems that involve multiple, usually conflicting criteria. These problems may involve personal decisions such as what or home to buy or may involve large scale decisions such as what products to produce in a company, which research and development projects to fund and so on. Within industry, the government and the military, individuals are making these types of decisions on a daily basis. Multiple Attribute Decision Making refers to making preference decisions over the available alternatives that are characterized by multiple, usually conflicting attributes. Multiple Attribute Decision Making is part of a larger category of problems, Multiple Criteria Decision Making (MCDM) which includes the category of Multiple Objective Decision Making (MODM). The nature of MODM problems differ somewhat from MADM problems in that their form and structure in that it involves designing the best alternative given a set of conflicting objectives. A MODM problem involves developing a model that has conflicting objectives subject to resource constraints and will allow for an infinite number of design possibilities. This course addresses MADM problems and further addresses MADM problem where the compensation across attributes are not allowed.

Multiple Attribute Decision-Making models rank alternatives based on several criteria measured with subjective and objective data. These decisions are made with attributes (criteria) and alternatives (choices) that represent the key considerations that are made. One important aspect of these decision-making problems is that both objective and subjective data can be used in solving the problem. Subjective data is typically forward-looking and represents the expert's opinion on the descriptive features of the attribute. Objective data, which is typically historical in nature, is typically the type of data you may find in a corporate database, analytical sources and raw data information that describes the status of the attribute in relation to the alternative being evaluated.

Other features of the multiple attribute decision-making problem include an attribute hierarchy, conflict among criteria, a hybrid nature, uncertainty, a large-scale problem, an ideal-solution, a non-dominated solution, a satisfying solution and preferred solution. For more

information in regard to the background and definition of MADM problems, please refer to the PDHengineer course Characteristics of Ranking Problems with Multiple attributes.

## **2.1 Non-Compensatory and Compensatory Decision-Making Methods**

Multiple attribute decision-making problems, or problems that rank alternatives fall into two broad categories of methods. The first category is non-compensatory, which means that trade-offs between attributes are not allowed in selecting an alternative. The second category is compensatory where the value of one attribute can compensate for a lower value in another attribute in the alternative selection process. Additional courses on compensatory methods have been developed for PDHengineer and are discussed in more detail in those courses. This course addresses non-compensatory methods that are useful in real-world problem-solving.

## **2.2 Non-Compensatory Methods**

Non-compensatory methods are multiple attribute decision making methods that do not permit trade-offs between attributes. This means that an unfavorable attribute value for given alternatives may not be traded-off with a favorable attribute value for the same alternative. In a sense, the attribute values stand on their own in respect to the qualification criteria for alternatives given the method selected. Attributes, then must stand on their own, and the unfavorable attribute value can eliminate the selection of an alternative even if all other attribute values for the alternative are excellent. MADM methods in the category are relatively simple to apply. They also can be used as a screening method for and used with other decision-making methods.

## **3.0 The Decision Matrix**

This section describes the decision matrix which is used to structure and solve multiple attribute decision-making problems. The decision matrix provides a structure to capture the key aspects of the decision being considered. It also provides a standard form that can be used to apply different methods to solve the decision problem at hand. The decision matrix can be used to apply both compensatory and noncompensatory MADM methods to arrive at a solution.

### **3.1 Definition of the Decision Matrix**

In general, there exist two distinctive types of MCDM problems. One type of problem has a finite number of alternative solutions and would be considered a multiple attribute decision-making problem and the other an infinite number of solutions which would be considered a multiple objective decision-making problem. Normally in problems associated with selection and assessment, the number of alternative solutions is limited. In problems related to design, an attribute may take any value in a range. This means that the potential alternative

solutions could be infinite. Our focus will be on the problems with a finite number of alternatives.

A MCDM problem may be described using a decision matrix. Suppose there are  $m$  alternatives to be assessed based on  $n$  attributes. A decision matrix is a  $m \times n$  matrix with each element  $a_{ij}$  being the  $j$ -th attribute value of the  $i$ -th alternative. Decision criteria or attributes are represented as  $C_j$ . Importance weighting associated with the decision criteria is represented at  $w_j$  and the alternatives under consideration are represented by  $A_i$ . Below is a representation of the decision matrix and a brief definition of the elements of the matrix.

<b>Weights</b>	<b><math>W_1</math></b>	<b><math>W_2</math></b>	<b>...</b>	<b><math>W_n</math></b>
<b>Alternatives/Criteria</b>	<b><math>C_1</math></b>	<b><math>C_2</math></b>	<b>...</b>	<b><math>C_n</math></b>
<b><math>A_1</math></b>	$a_{11}$	$a_{12}$	...	$a_{1n}$
<b><math>A_2</math></b>	$a_{21}$	$a_{22}$	...	$a_{2n}$
<b>...</b>	...	...	...	...
<b><math>A_m</math></b>	$a_{m1}$	$a_{m2}$		$a_{mn}$

**Criteria:** A criterion or attribute is a measure of effectiveness. It is the basis for evaluation. Criteria emerge as attributes or objectives in the actual problem setting. In multiple attribute decision making they can be viewed as performance parameters, components, factors, characteristics and properties. An attribute should provide a means of evaluating the level of an objective. Each alternative can be characterized by a number of attributes, based on those elements that are important in the decision process.

**Weights:** Not all attribute are equally important when making a decision. Minimizing cost, for example, may be far more important than maximizing comfort. By assigning weights to the decision criteria or attributes, the decision-maker or team can represent their value of importance in the ultimate decision. As a note, not all decision methodologies support criteria weighting, therefore it is necessary to select a method that is representative of the types of considerations that the decision-maker or makers wish to consider.

**Alternatives:** Alternatives are those potential choices that a decision-maker can select based on his or her evaluation of the key aspects of the decision. You, for example, maybe deciding to purchase a car and use a decision matrix for your evaluation process. Your alternatives are the different types of cars that you are considering, and the decision criteria or attributes are those elements that are important to you in your decision-making process.

**Attribute Value for Alternatives:** These values are the representation of the performance level for an alternative as it is associated with each attribute. For a given alternative, there is a scoring

of each attribute to represent the value and consideration associated with the alternative. These evaluations are the data that are used in the evaluation process.

The decision matrix is the fundamental construction of the multiple attribute decision-making problem and is used as a basis for applying the numerous different types of decision-making methods that can be used to solve multiple attribute decision-making problems. The development of the attributes, alternatives, importance weighing, and data used in the decision matrix is important to developing a well-structured decision problem. Also, the development of the decision matrix is an important activity that can be used to gain consensus from the key decision-makers on the key considerations that are used in the decision process. Group decision-making techniques can be used to support this process. Group decision-making techniques are discussed in detail in another PDHengineer course developed by this author.

## **4.0 Non-Compensatory Methods**

This section describes a number of methods that are classified as non-compensatory multiple attribute decision making methods. Although the actual name of the method may be unfamiliar, the types of problems that may be solved with these methods may be much more familiar than the student expects. These methods may be methods that you use, however, were unaware that there is a formalized approach associated with the application of the method.

This section will discuss the steps and processes required to use these methods. Additionally, an example will be provided so that the student may use these methods in their personal and professional circumstances.

### **4.1 The Dominance Method**

The Dominance method is used to reduce the number of alternatives in a set of alternatives by eliminating those alternatives that are worse across all attributes than another alternative. The use of this method is helpful for developing a set of alternatives that ensure that you are selecting alternatives from the best possible solution. In general, the dominance method could be used prior to the use of any other multiple attribute decision-making methods. There is no need to keep alternatives under consideration if there is an alternative that is clearly better across all attributes.

An alternative is dominated if there is another alternative that excels in one or more attributes and equals it in the remainder. The number of alternatives can be reduced by eliminating the dominated ones. Basically, we use this method to screen the set of alternatives before the decision is made to avoid selecting an inferior alternative. This process enables us to arrive at a set of solutions that are not bettered by other solutions, or a set of nondominated solutions.

Many methods require some type of transformation of the attribute into like units. In general, when you have attribute measures such as dollars, you cannot aggregate dollars with, for example, miles per hour, without some transformation of the attribute value to a common unit. This method does not require this transformation which is helpful in assessing the alternatives with a real-world perspective. This method is accomplished in the following manner.

1. Compare the first two alternatives on an attribute by attribute basis. If one is better across all attributes or dominated by the other, discard the dominated alternative.
2. Next compare the un-discarded alternatives with the third alternative and discard any dominated alternative.
3. Then introduce the fourth alternative and repeat the process.
4. After  $(m - 1)$  steps, only one alternative remains.

This nondominance method is mainly used for the initial filtering of the alternatives.

#### 4.1.1 Example Use

The following example illustrates the use of the nondominance method in a food manufacturing plant. The decision-makers identified three attributes that they feel are important: cost, community attitude, and environmental issues. An assessment of the community attitude at the plant, there could be issues from citizens or the plant, there could be processing plant, it is important to consider the plant being a food processing plant. Locations that have had water allocation issues are consistent production capabilities. Additional information would rather avoid selecting a site with a site that is not associated with these three attributes or criteria. The table below.

*To view the remainder of the course material and to take the quiz for PDH credit, you must purchase the course.*  
*Close this window and click "Add to cart" on the product page.*