ANNALS of the ORADEA UNIVERSITY.

Fascicle of Management and Technological Engineering, Volume VII (XVII), 2008

USING THE MULTI-CRITERIA ANALYSIS (MCA) IN THE DRAFTING OF DOCTORATE PAPERS

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Keywords: technique, analysis, multi-criteria, doctorate

The first part of the paper presents the steps of the multi-criteria analysis, highlighting its advantages. The second part of the paper presents 4 potential situations for using this analysis within a doctorate paper. Furthermore, a few of potential criteria types that may be used are proposed.

The multi-criteria analysis is useful for putting together a classification (of different solutions to the same problem) at the same time quantitative and qualitative, by regarding several criteria. The quantitative view: the calculation of a score for every analyzed solution. The quantitative view: the ordering (growing or decreasing) of the solutions based on a calculated score.

A criterion is a clearly defined point of view, of the specialist in the scope. The criterion delimitates, defines certain properties, attributes, characteristics of the solutions that are analyzed. Unlike other techniques, MCA is able to work with a large, even very large, number of criteria. Usually only the main, major criteria are considered. It is forgotten that sometimes, the overlooking of a number of secondary, minor criteria may overturn the assembled classification based only on the main or major criteria.

Although there are many similar techniques (methods), we consider that among them the Multi-Criteria Analysis distinguished itself among them through an increased degree of objectivity. The objectivity is implied by:

- Establishment, based on calculations, of the weight factor of each criterion. The calculation of the weight factor is made by comparing in turn two criteria at one time.
- Bestowing marks for each solution, in turn, based on a single criterion.
- The calculation of the final score taking into consideration the weight factor of each criterion.

A simple example may be concluding for the demonstration of the objectivity of this analysis, for each user separately. Let's presume the case of two users (one that is financially well-off, the other not) analysing what car to buy. It is presumed, that they consider the same type of vehicles, analyzed through the same prism of criteria. Certainly, the results of the two buyers won't be identical, quite the opposite. But for each user, from his point of view, the result is objective. This relative objectivity is what satisfies each user.

The weight factor of the Multi-Criteria Analysis is assessed by calculating the weight factors γ_i on three value *Latin grid*.

A quadratic table is composed, which has on the rows and also on the columns the respective criteria numbered N_{crt}. In this table each criterion is compared against the others, with the entry on the each row and exit on each the column. When the criterion is on a row compared with the criterion on a column if it is:

- more important, the value 1 is assigned;
- equally important, the value ½ = 0,5 is assigned;
- less important the value 0 is assigned.

On the main diagonal of the quadratic table of criteria, only values of ½ = 0,5 are entered. Explanation: a criterion can not be more or less important than itself. Consequently, when values are attributed to the elements of the quadratic table, **in the first phase** the main diagonal has to be filled with values of ½ = 0,5. **In the second phase** values are established and attributed only to the elements above the main diagonal (utilizing the reasoning from the previous paragraph). **In a third phase** values are established for the elements below the main diagonal, as conjugates of the element values above the main diagonal. For the conjugate values the following must be regarded:

- The value **1** attributed to an element above the main diagonal implied the attributing of the conjugated value of **0** the symmetrical element relative to, and below, the main diagonal.
- The value **0** attributed to an element above the main diagonal implied the attributing of the conjugated value of **1** the symmetrical element relative to, and below, the main diagonal.
- The value **½ = 0,5** attributed to an element above the main diagonal implied the attributing of the conjugated value of ½ = 0,5 the symmetrical element relative to, and below, the main diagonal.

A useful verification: the sum of all points (values) in such a table is always equal to half of the square of criteria number.

On each row the sum of all criteria is calculated, thus establishing the level (placement) compared to the others. The value of the level concurs with the place in the classification of the criteria. On the first level (first position) will be placed the criterion that obtained the highest number of points. On the last level (last position) will be placed the criterion that obtained the lowest number of points. If two (or more) criteria score the same number of points, the level will have as value the semi-sum (or if there are more, the arithmetic mean) of places (successive) of the respective criteria in the classification of the criteria; thus the level can also be a decimal ratio. The weight factors (γ_i) can be calculated with different formulae. For the practical application the FRISCO formula (empiric formula given by a renowned creation group from San Francisco - USA) was chosen, a formula which has been recognised world wide as being the most performant and mostly used:

$$\gamma_i = \frac{p + \Delta p + m + 0{,}5}{-\Delta p' + \frac{N_{crt}}{2}} \qquad (1)$$

where:

p is the sum of the points (on a row) scored by the analysed element;

Δp – the difference between the score of the analysed element and the score of the element on the last level; if the regarded element is the element on the last level, Δp will have the value 0;

m – number of criteria outranked (standpoint of the score) by the regarded criterion;

N_{crt} – number of regarded criteria;

$\Delta p'$ – difference between the score of the regarded criteria and the score of the first criteria (resulting in a negative value); if the regarded criteria is the one place on the first level, the result will be 0.

After the calculus of the weight factors, each variant is marked (with an integer from 1 to 10). The mark is awarded to each variant, according to each criterion. That means each variant is analysed in turn, through each criterion, until all variants are assessed.

At last the sum of these product is being calculates; the sums (usually unique values, associated to each variant) will determine a final classification.

A few examples using the Multi-criteria Analysis can be found in [BOC2003, p. 251-258] or in [www01].

During the drafting of a doctorate paper, several steps are predictable in which the MCA can be applied successfully. Some general criteria are proposed, which can be used in many of the fields of doctorate papers.

1. The Multi-Criteria Analysis may be applied for establishing the topic of a doctorate thesis, when several topics are being considered. Some of the usable criteria are:
   - The degree to which the topic is attractive to the student.
   - The degree to which the topic is attractive to the leading professor.
   - The degree of practical applicability.
   - The (estimated) speed of solving the topic.
   - The overlaying of the topic with some job responsibilities (for the working students).
   - The possibility of attracting funds.
   - The possibility for ulterior research directions.
   - The (estimated) financial efficiency etc.
2. After the research phase of a doctorate thesis is concluded, several solutions are usually found in the bibliography to solve the proposed topic. The ordering of the existing topics is useful especially through the prism of the score value of the variants. Some of the usable criteria are:
   - The expense of the first application at the place targeted by the doctorate thesis.
   - The cost over extended periods of time.
   - The implementation time.
   - The attained savings.
   - The period of time after which moral wear appears.
   - The modernizing-actualizing possibilities.
   - The impact on the environment.
   - The complexity degree etc.
3. When the actual problem solving is approach, the working method may become the subject of a Multi-Criteria Analysis. For example, it's interesting to establish (by comparison) a classification (objective to the doctorate student) of some solving methods (analytic, numeric, graphic-analytic, analogical, experimental, theoretic-experimental etc.). Some of the usable criteria are:
   - The understanding and usability possibilities by the doctorate student.
   - The possibility of working with other experts t use the method.
   - Efficiency.
   - Precision.
   - Work volume.

- Costs.
- Necessary equipment.
- The possibility (if warranted) of training other users etc.

4. Finally, the thesis proposes one or several new variants of solving the topic. After this phase, the new creations in the thesis can be compared with the existing solutions which are apt to be used in the place targeted by the thesis. Such a classification objectively places the contributions in the thesis in regard with the solution already existing. Most of the criteria from the second point can be used and also:
   - The removal of some existing deficiencies or disadvantages.
   - Opinions (if they have already been obtained) of the specialists in the field.
   - Concrete possibilities of realisations at the place targeted by the thesis etc.

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