

NAIADE Method: a short description

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NAIADE (**N**ovel **A**pproach to **I**mprecise **A**ssessment and **D**ecision **E**nvironments) is a discrete multicriteria method developed by G. Munda (1995) whose impact (or evaluation) matrix may include either crisp, stochastic or fuzzy measurements of the performance of an alternative with respect to an evaluation criterion, thus it is very flexible for real-world applications.

A peculiarity of NAIADE is the use of conflict analysis procedures to be integrated with the multi-criteria results. NAIADE can give the following information:

- ranking of the alternatives according to the set of evaluation criteria (i.e. technical compromise solution/s);
- indications of the distance of the positions of the various interest groups (i.e. possibilities of convergence of interests or coalition formations);
- ranking of the alternatives according to actors' impacts or preferences (social compromise solution).

From a methodological point of view, two main issues are faced:

- the problem of equivalence of the used procedures in order to standardise the various evaluations (of a mixed type) of the performance of alternatives according to different criteria;
- the problem of comparison of fuzzy numbers typical of all fuzzy multicriteria methods.

These 2 methodological issues are dealt with a new semantic distance that is useful in the case of continuous, convex membership functions allowing also a definite integration.

If $\mu_{A_1}(x)$ and $\mu_{A_2}(x)$ are two membership functions, we can write

$$f(x) = k_1\mu_{A_1}(x) \quad \text{and} \quad g(y) = k_2\mu_{A_2}(x)$$

where $f(x)$ and $g(y)$ are two functions obtained by rescaling the ordinates of $\mu_{A_1}(x)$ and $\mu_{A_2}(x)$ through k_1 and k_2 , such as the area of $f(x)$ and $g(y)$ is equal to 1.

The distance between all points of the membership functions is computed as follows:

$$S_d(f(x), g(y)) = \int_x \int_y |x - y| f(x)g(y) dydx$$

Therefore, when the intersection is empty, their distance is equal to the distance between their expected values. When the intersection between two fuzzy sets is not empty, their distance is greater than the difference between the expected. In this case one finds

$$S_d(f(x), g(y)) = \int_{-\infty}^{\infty} \int_x^{\infty} (y-x) f(x)g(y) dydx + \int_{-\infty}^{\infty} \int_{-\infty}^x (x-y) f(x)g(y) dydx$$

From a theoretical point of view, the following conclusions can be drawn:

- (1) the absolute value metric is a particular case of this type of distance;

- (2) the comparison between a fuzzy number and a crisp number is equal to the difference between the expected value of the fuzzy number and the value of the crisp number considered;
- (3) by means of this semantic distance, the problem of the use of only one side of the membership functions, common to most of the traditional fuzzy multicriteria methods, is overcome.
- (4) Also stochastic information can be taken into account.

The whole NAIADE procedure can be divided in four main steps:

- (1) pairwise comparison of alternatives according to each criterion,
- (2) aggregation of all criteria,
- (3) ranking of alternatives,
- (4) social conflict analysis.

The comparison between the criterion scores of each pair of actions is carried out by means of the semantic distance. Another important advantage of the preference modelling introduced in NAIADE is towards sensitivity analysis. The modelling procedure based on the notion of a pseudo-criterion, may present a serious lack of stability. Such undesirable discontinuities make a sensitivity analysis (or robustness analysis) necessary; however, this important analysis step is quite complex to manage because of the combinatorial nature of the various sets of data. One should combine variations of two thresholds and k scores of the M criteria. The use of fuzzy set approaches, since small variations of input data (scores, thresholds) will modify in a continuous way the resulting preference model can allow one to avoid these drawbacks.

A first possible approach is to associate a fuzzy outranking relation with a pseudo-criterion as in ELECTRE III or to use a generalised criterion as in PROMETHEE. It has to be noted that both methods require that some parameters have to be fixed. A second approach may be the use of fuzzy criterion scores; however, in this case the problem of comparison of fuzzy numbers arises.

This is the reason why in NAIADE a method based on both the underlying philosophy of a "fuzzy pseudo-criterion" and the use of fuzzy criterion scores is used (see figures 1 and 2).

Given the information on the pairwise performance of the alternatives according to each single criterion, it is necessary to aggregate these evaluations in order to take all criteria into account simultaneously. This is done by using a kind of concordance index aggregating the various credibility degrees obtained according to the criteria used.

The final ranking of the alternatives in a complete or partial preorder (γ problem formulation), is obtained by means of the basic idea of positive (leaving) and negative (entering) flows of the PROMETHEE methods.

Finally, in the framework of an equity analysis, it is possible to evaluate the impact of different actions on different income/interest groups (see figures 3 and 4).

Reference

G. munda (1995) – *Multicriteria evaluation in a fuzzy environment*, Contributions to economics Series, Physica-Verlag, Heidelberg.

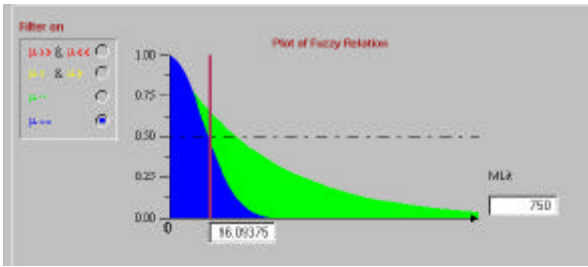


Figure 1. Credibility degrees of indifference relations

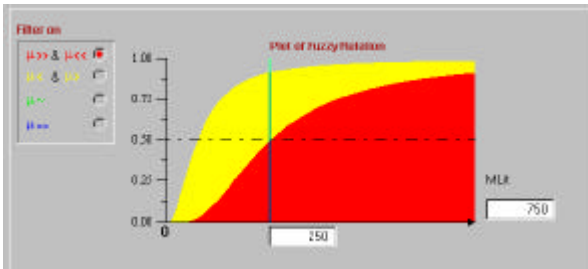


Figure 2. Credibility degrees of preference relations

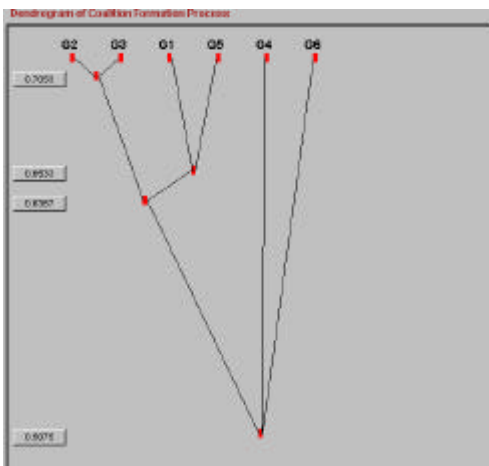


Figure 3. Credibility degrees of possible coalitions

{03,02,05,01}	{04}	{06}
F 0.13	B 0.09	B 0.09
G 0.94	C 0.08	C 0.09
H 0.85	D 0.09	D 0.09
A 0.99	G 0.09	E 0.09
C 1.11	F 0.09	F 0.09
B 1.11	A 0.08	A 0.09
D 1.27	E 0.09	G 0.78

Figure 4. Ranking according to different possible coalitions