BISER

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INTRODUCTION

The Simon's model of the decision-making process includes the phase of choosing among alternatives or options, designed for solving the given problem. Usually an option dominates in some of the properties and is less suitable according to others. Making a rational decision in choosing an option means to balance between different properties. There are two principle strategies in performing this task:

- To evaluate every option on the whole set of properties, and
- To apply a procedure to extract the best (the most suitable) one.

Integration of information associated with the multiple properties of competitive options into a single measure is presented and discussed. Options could be goods to purchase, list of products for manufacturing, suppliers, services, technologies, and even candidates for a given position. The common in all such cases are:

- The decision maker has to assign a value to every option in the competing group by comparing it against its alternatives—the other members of the same group. Further, we shall call this value **integral quality indicator** of the option.
- Options in the group are described with a common list of properties or characteristics, which we will call further **single quality indicators** of the option.

Different measures, designed to integrate the information provided by single indicators, are presented and discussed.

INFORMATION MODEL: NOTATIONS

The elements we will use further are presented in Table 1:

- $O = \{O_i\}$, $i = 1,\ldots n$ is the group of options;
- $I = \{I_j\}$, $j = 1,\ldots,k$ is the set of single indicators;
- $X = \{x_{ij}\}$, $i = 1,\ldots,n$; $j = 1,\ldots k$ is the information matrix, holding the value of single indicator I_j for option O_i;
- $W = \{w_j\}$, $j = 1,\ldots,k$ is the vector of weights, where w_j measures the value (importance, significance) of the indicator I_j;
- $S = \{s_j\}$, $j = 1,\ldots k$ is the vector of signs, where s_j represents the direction of increasing the quality of options according to the change of the value of given indicator: "'+1" indicates "the higher value of the indicator the higher quality of the option" and "-1" indicates "the higher value of the indicator, the lower quality the option." In this case, when quality of the option, measured according to indicator I_r, depends on the distance from a given finite value y_r, and it is the highest when $x_{*r} = y_r$, we may apply the following transformation $x_{jr} = abs(x_{jr} - y_r)$ and set the sign as $s_r = -1$.

INTEGRAL INDICATORS

Integral indicators are functions I, which transform a vector $\{x_j\}$ of real numbers into a single real number Q, where $j = 1, 2, \ldots, k$.

$$I : R^n \to R$$

Table 1. Information model

				option 1	option 2	...	option n
indicator	**dimension**	**weight**	**sign**	O_1	O_2	...	O_n
I_1	D_1	w_1	s_1	x_{11}	x_{21}	...	x_{n1}
I_2	D_2	w_2	s_2	x_{12}	x_{22}	...	x_{n2}
...	...	...	...	...	...	...	...
I_k	D_k	w_k	s_k	x_{1k}	x_{2k}	...	x_{nk}

Weighted average (Additive Integral Indicator) is the most often used integral indicator:

$$I(O_i) = \frac{1}{\sum_{j=1}^{k} w_j} \sum_{j=1}^{k} w_j q_{ij}, i = 1,2,...,n,$$

where

$$q_{ij} = \left(\frac{x_{ij}}{\overline{\overline{x_j}}} \right)^{S_j} \text{ and } \overline{x_j} = \frac{1}{k} \sum_{i=1}^{n} x_{ij}.$$

It is easy to interpret results achieved by weighted average but if single indicators are not independent, a hidden bias may influence the result. This indicator may lead to misinforming, when the values of single indicators are spread near the boundaries of their domains. In this case, a poor value of one indicator can be compensated with even tiny dominance of another even less important indicator.

To avoid the later problem, a multiplicative integral indicator (see Boneva, Dimitrov, Stefanov, & Varbanova, 1986) was constructed:

$$I(O_i) = \prod_{j=1}^{k} q_j^{w_j}, i = 1,2,...,n,$$

where $\{w_j\}$ are appropriately normalized, and q_{ij} has the same meaning as in additive formula. Independence of single indicators is required as well. The quantity of information (using Shannon's formulae) obtained by this integral indicator is equal to the weighted sum of quantities of information provided by single indicators (see Christozov, 1997):

$$\log_2 I(O_i) = \sum_{j=1}^{k} w_j \log_2 q_j, i = 1,2,...,n.$$

The difficulty in interpreting this measure in the problem domain may cause misinforming. It also assumes independence of single quality indicators.

BISER (Christozov, Denchev, & Ugarchinsky, 1989) is an algorithm, exploring between indicators dependences, which constructs a family of integral indicators. Linear regression is used to assess the existing dependency between a pair of indicators I_v and I_w. Four simple regression models are used, obtained via transforming original data by taking logarithms of the values of either one or another or both of the vectors, representing indicators I_v and I_w, which are used in evaluation of the regression coefficients:

model 1: $x_v = a_{vw} + b_{vw} x_w$
model 2: $x_v = a_{vw} + b_{vw} \, ln(x_w)$
model 3: $x_v = exp(a_{vw} + b_{vw} x_w)$
model 4: $x_v = exp(a_{vw} + b_{vw} \, ln(x_w))$

The model that gives the highest correlation C_{mvw} is selected. The correlation coefficient is used also as a measure for the between indicators dependency. The intermediate result consists of the four matrices:

regressions' coefficients $A = \{a_{ij}\}$ and $B = \{b_{ij}\}$
correlation coefficients $C = \{c_{ij}\}$
selected model $M = \{m_{ij}\}$

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